Views of the Library Room.

BROOKLYN ENGINEERS' CLUB.

ORGANIZED OCT. 9, 1896.
INCORPORATED DEC. 29, 1896.

PROCEEDINGS

FOR 1899,

CONSTITUTION AND BY-LAWS

WITH

LIST OF MEMBERS

AND

CATALOGUE OF REFERENCE WORKS IN THE LIBRARY.

JANUARY, 1900.

PRICE, TWO DOLLARS.

Office of Secretary, 191 Montague Street,
Library of Club in Brooklyn Library Building, Montague St., near Fulton,
Brooklyn, N. Y. City.

BROOKLYN ENGINEERS' CLUB.

CONTENTS.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME, LOCATION AND OBJECT.

Section 1. The name of this Association shall be the

"Brooklyn Engineers' Club."

Sec. 2. The offices of the Club shall be located in the City of Brooklyn.

Sec. 3. The object of the Club shall be to promote social and professional intercourse among its members; to advance engineering knowledge and practice, and to maintain a high standard of professional procedure in all respects.

Sec. 4. The means to be employed for this purpose shall be: Meetings for the presentation and discussion of appropriate papers and for social and professional intercourse; the publication of such papers and discussions as may be deemed expedient; the maintenance of a technical library, and such other means as may be deemed proper.

ARTICLE II.

MEMBERSHIP.

Section 1. The Club shall consist of Corporate, Associate, Non-Resident and Honorary members.

Sec. 2. A Corporate member shall be a civil, military, naval, mechanical, electrical, mining or other engineer, architect, surveyor or analytical chemist, or a person who has taken a course in a technical school with the purpose of entering one of the above-mentioned professions. He shall be either a resident of Brooklyn, or one of the other Boroughs of the City of New York, or a practitioner therein, at the time of his election.

Sec. 3. An Associate member shall be a person residing, or doing business in Brooklyn, or another Borough of the City of New York, at the time of making his application, who has such a knowledge of or connection with applied science as qualifies him, in the opinion of the Board of Directors, to co-operate with engineers in the advancement of professional knowledge.

Sec. 4. A Non-Resident member shall be one possessing the qualifications enumerated in Sections 2 and 3, whose residence and place of business are both outside of the City of New York.

Sec. 5. A Corporate or Associate member who shall remove his residence and place of business to the distance stated in Section 4, may be transferred to the Non-Resident class at the beginning of the fiscal year following such removal, provided notice of the removal be filed with the Secretary at the time of payment of the annual dues, or not later than February 1st.

Sec. 6. A Non-Resident member who shall remove his residence or place of business to within the City of New York, shall become a full member in the same manner as specified in Article III, but shall not be required to pay an entrance fee. Provided, however, that his application for full membership shall be filed within three (3) months of his removal, otherwise his name shall be dropped from the roll of the Club by the Board of Directors at the beginning of the next calendar year, except that no action shall be taken unless a copy of this section shall have been served upon him at least four (4) weeks prior to such action.

Sec. 7. Honorary members shall be chosen from persons resident in Brooklyn, of acknowledged eminence in the pursuit of their profession, or on account of their contributions to the welfare of the community along professional or municipal lines. There shall not be more than five (5) Honorary members at any one time.

Sec. 8. Associate, Non-Resident, and Honorary members shall not be entitled to vote or hold office, but shall enjoy all other Club privileges, except that Non-resident members shall not be entitled to the library privileges.

ARTICLE III.

ADMISSIONS AND EXPULSIONS.

Section 1. An application for admission to the Club as a Corporate member or for transfer from the Non-Corporate to the Corporate grade, shall embody a concise statement, with dates, of the candidate's professional training and experience, and shall be in a form and in such detail as may be prescribed by the Board of Directors. It shall be signed by the applicant, and shall contain a promise to conform to the requirements of membership if elected. The applicant shall give at least three (3) references, two of whom shall be Corporate members in good standing.

Sec. 2. The above application shall be made through the Secretary, who shall post the name of the applicant on the bulletin board of the Club, and transmit the application to the President.

The qualifications of the applicant for membership shall be referred to the Committee on Membership, or, if the President deem it advisable, to a special committee of three (3) members to be appointed by him. It shall be the duty of this Committee to thoroughly investigate the personal and professional fitness of the candidate, and to report in writing the result of said investigation to the Board of Directors as soon as practicable thereafter.

When this report shall have been made to the Board of Directors, the said Board shall present the application, if approved by them, at the next regular meeting of the Club, or as soon thereafter as possible, or withhold it at their discretion, except that upon a written request of five (5) Corporate members to the Board of Directors, said Board shall submit said application at the next regular meeting of the Club, together with the report as to why said application had been withheld.

Sec. 3. An application which shall have had the approval of the Board of Directors shall be balloted upon at a regular meeting by the members present, provided a notice to that effect shall have been given by the Secretary to the members of the Club. A four-fifths ($\frac{4}{5}$) vote of those voting shall be necessary for election.

Sec. 4. The application of any candidate, once rejected, shall not be considered by the Board of Directors, within one year, unless the same be accompanied by a request signed by not less than five (5) Corporate members asking for a reconsideration of the ballot, and stating the reason for such request. The Board of Directors, should it deem those reasons sufficient, shall present said application at the next regular meeting of the Club, with the request that it be acted upon.

Sec. 5. All elected candidates shall be duly notified and shall subscribe to the Constitution and Rules of the Club.

If these provisions are not complied with within thirty (30) days from the notification of election, such election shall be considered void unless, for special reason the time shall be extended by the Board of Directors. Membership of any person shall date from the day of his election.

Sec. 6. Honorary members shall be proposed by the Secretary upon the unanimous recommendation of the Board of Directors at a regular meeting, and be balloted upon at the next regular meeting. Four-fifths ($\frac{4}{5}$) of the votes cast shall be necessary for an election.

A person elected an Honorary member shall be promptly notified thereof by letter; the election shall be canceled if an acceptance is not received within ninety (90) days after mailing such notice.

Sec. 7. Upon the written request of six or more Corporate members, that for cause therein set forth a person belonging to the Club be expelled, the Board of Directors shall consider the matter, and, if there

appear to be sufficient reason, shall advise the accused of the charges against him. He may, if he so desire, present a written defense, which shall be considered at a meeting of the Board of Directors, of which he shall receive due notice and at which he may appear with counsel. Unless the defense made be satisfactory to the Board of Directors, they shall, after two months have elapsed, unless his resignation has already been tendered, notify the person that he must present the same within thirty (30) days, or he will then be expelled.

An appeal may be taken against such a course, in which case a special meeting will be called for the purpose of submitting to the Club all the evidence in the case. A majority of the votes cast at this special meeting will be required to sustain the action of the Board. The Secretary will notify all Corporate members of the Club of the result of the ballot. In case no appeal be made, the Board of Directors will expel the person and notify him and the Corporate members of its action.

Sec. 8. A member of any grade in the Club may resign his membership by a written communication to the Secretary, who will present the same to the Board of Directors; when, if his dues have been paid, his resignation will be accepted.

ARTICLE IV.

ENTRANCE FEES AND DUES.

Section 1. The dues on admission to the Club and yearly thereafter shall be:

For Corporate member, Eight (8) Dollars.
For Associate member, Six (6) Dollars.
For Non-Resident member, Three (3) Dollars.

Sec. 2. Corporate, Associate and Non-Resident members shall pay an entrance fee of Five Dollars upon admission to the Club.

The annual dues shall be payable for the ensuing year on the first day of January.

It shall be the duty of the Secretary to notify each member of the amount due for the ensuing year at the time of giving notice of the annual meeting.

Sec. 3. A person elected after six months of any fiscal year shall have expired shall pay only one-half of the amount of dues for that fiscal year.

Sec. 4. Any person whose dues are more than one month in arrears shall be notified by the Secretary. Should his dues not be paid when they become three months in arrears, he shall lose all library privileges secured through the membership in the Club, and lose his

right to vote. Should his dues become four months in arrears he shall again be notified in form prescribed by the Board of Directors, and should such dues become six months in arrears he shall forfeit his connection with the Club. The Board of Directors may, for cause deemed by them sufficient, extend the time for payment and for application of these penalties.

Sec. 5. The Board of Directors may, for sufficient cause, reduce the annual dues of any member to three (3) dollars, and of any Associate member to one (1) dollar, provided all Library privileges are waived by the person making application therefor, which must be in writing.

Sec. 6. Every member admitted to the Club shall be considered as belonging thereto, and liable for payment of dues until he shall have resigned or been expelled therefrom.

ARTICLE V.

OFFICERS.

Section 1. The officers of the Club shall be a President, Vice-President, Secretary and Treasurer, who with the retiring President shall constitute a Board of Directors in which the government of the Club shall be vested, and who shall be the Directors as provided for by the laws under which the Club is incorporated.

Sec. 2. The President shall be ineligible for election to two successive terms of office.

Sec. 3. The term of office for all officers shall be one (1) year, except for the Vice-President, who shall hold office for two (2) years.

Sec. 4. A vacancy in the office of President shall be filled by the Vice-President.

Sec. 5. At the first annual meeting there shall be elected a Trustee, who shall act as a member of the Board of Directors and shall serve for one year. Any vacancy occurring in the Board by resignation, death or otherwise, shall be filled for the unexpired term by its remaining members.

Sec. 6. All officers shall be elected by ballot.

ARTICLE VI.

MANAGEMENT.

Section 1. The President, acting under the direction of the Board of Directors, shall exercise a general supervision over the affairs of the Club. He shall preside at all business meetings of the Club and Board of Directors at which he may be present, call special meetings when

the same may be necessary, and appoint such committees as are herein provided for. He shall act as *ex-officio* member of all committees which he shall appoint.

SEC. 2. The Vice-President shall preside at business meetings in the absence of the President.

SEC. 3. The Board of Directors shall manage the affairs of the Club in conformity to the laws under which the Club is incorporated, and the provisions of this Constitution. They shall direct the investment and care of the funds of the Club; make appropriations for specific purposes; act upon applications for membership, as heretofore provided; constitute the Auditing Board, and generally conduct the business of the Club. The Board of Directors shall make an annual report at the annual meeting, transmitting the report of the Treasurer and of other officers and committees.

SEC. 4. The Secretary, under the direction of the President and the Board of Directors, shall be the executive officer of the Club. He shall keep a record of all business meetings. He shall notify the members of all meetings and postponements thereof, and of all other matters as directed by the President and the Board of Directors. It shall also be his duty to take charge of and preserve all papers read and discussed, and, when directed by the Board of Directors, prepare copies or abstracts of the same for publication.

SEC. 5. The Treasurer shall collect and have charge of all funds, and shall deposit the same to the credit of the Club in such depository as may be directed by the Board of Directors. He shall pay all bills duly approved, by check countersigned by the President, and shall keep book accounts of his receipts and his expenditures, which shall be at all times open to inspection by the Board of Directors. He shall present a monthly report to the Board, showing receipts and expenditures during the previous month. He shall make an annual report to be audited and presented to the Club by the Board of Directors.

SEC. 6. The President, within ten days after the annual meeting, shall appoint a Library Committee of three, a Committee on New Membership of three, and an Entertainment Committee of three, members of the Club, which committees shall be subject to the direction of the Board of Directors.

SEC. 7. The Library Committee shall have general charge of the Library and shall take the necessary steps to procure all books, periodicals, transactions, reports, publications, etc., etc., that may be needed; present prior to the annual meeting a report to the Board of Directors, showing the increase in the Library during the year, and a statement of the moneys expended; also present an estimate of the money needed for Library purposes for the coming year.

Sec. 8. The Committee on New Membership shall investigate the fitness of all candidates for membership that may be referred to them by the President; see that the objects and advantages of the Club are at all times kept before the community in a proper spirit, and, generally, see that the Club preserves a healthy and desirable growth.

Sec. 9. The Entertainment Committee shall have charge of arrangeing the social features of all meetings, and shall provide suitable papers to be presented before the Club. It shall be their duty to transmit all necessary information concerning the same to the Secretary in time for inserting notice in the notification of meetings.

ARTICLE VII.

MEETINGS.

Section 1. There shall be eight (8) regular meetings of the Club per annum, to be held on the second Thursday in each month, except during the months of June, July, August and September.

Sec. 2. The annual meeting, at which the officers for the ensuing year shall be elected and all annual reports read, shall be held on the second Thursday of December in each year.

Sec. 3. Whenever the President shall deem it necessary, or upon the written application of five (5) Corporate members, he shall direct the Secretary to call a special meeting. The notice thereof shall state the time and place of holding the meeting and the purpose for which it is called, and shall be mailed not less than five days previous to the date of the proposed meeting.

Sec. 4. At all regular and special meetings of the Club, ten (10) Corporate members shall constitute a quorum.

Sec. 5. The Club may adopt, from time to time, rules for the order of business at its meetings.

Sec. 6. At the regular or special meeting of October, 1897, and annually thereafter, a committee of five (5) Corporate members shall be elected by the members present to make nominations for officers to be balloted for at the ensuing annual election. Said Committee shall report their list of nominations at the regular meeting in November, and the list shall be sent to each Corporate member by the Secretary, in the regular notification of the annual meeting. And it shall be the duty of the Secretary to send with such nominations any other nominations, on the written request of five (5) Corporate members filed with him ten (10) days before the date of the annual meeting. The said notices shall be mailed by the Secretary one week before the annual election.

In the event of failure to elect a Nominating Committee at an October meeting, it shall be the duty of the Board of Directors to appoint such committee.

ARTICLE VIII.

AMENDMENTS.

Section 1. Proposed amendments to this Constitution must be reduced to writing and signed by not less than five (5) Corporate members, and be submitted and acted upon as follows:

Sec. 2. The amendment, as proposed, shall be sent by letter to the several Corporate members, with the statement that the matter will come up before the next regular meeting for discussion unless otherwise ordered.

Sec. 3. At the discussion the proposed amendment may be amended in any way by a majority of those present and voting.

Sec. 4. The amendment, as amended, shall then be sent by letter to the several Corporate members, wherein the meeting for final action thereon will be announced. When final action is taken, a two-thirds ($\frac{2}{3}$) vote in favor of said amendment, as amended, will be necessary for its adoption.

BROOKLYN ENGINEERS' CLUB.

LIST OF OFFICERS AND MEMBERS, 1896.

Temporary President, ANDREW J. PROVOST, JR.

Temporary Secretary, WILLIAM G. FORD.

Temporary Treasurer, GEORGE W. TILLSON.

Committee on Constitution and By-Laws and Committee on Library:

A. J. CALDWELL, GEORGE W. TILLSON, WALTER M. MESEROLE, A. J. PROVOST, JR., WILLIAM G. FORD.

Committee on Incorporation:

A. J. PROVOST, JR., WILLIAM G. FORD.

CHARTER MEMBERS.

O. F. Balston,
Fred. L. Bartlett,
Homer L. Bartlett,
Herbert J. Barker,
W. L. Beers,
R. T. Betts,
William E. Belknap,
Francis Blossom,
J. C. Brackenridge,
David Brower,
William T. Bruorton,
Edmund J. Burke,
Andrew J. Caldwell,
D. Frederick Carver,
Frank J. Conlon,
Albert S. Crane,
Frederick A. Drake,
John H. Dwyer,
William G. Ford,
Edwin J. Fort,
Arthur J. Griffin,
Thomas S. Griffin,
Walter R. Griffith,
George T. Hammond,
Arthur S. Ives,
Carl A. Johnsen,
Jacob Stinman Langthorn,
J. Calvin Locke,
Edward L. Maltby,
James C. Meem,
Walter M. Meserole,
Peter Milne,
Frank O. Nowaczek,
Arthur I. Perry,
Frederick E. Pierce,
Clarence D. Pollock,
Andrew J. Provost, Jr.,
*G. S. Roberts,
George F. Rowell,
Joseph Strachan,
Edwin C. Swezey,
George W. Tillson,
Kenneth Torrance,
Arthur S. Tuttle,
William D. Vanderbilt,
*John H. Van der Veer,
Bernard M. Wagner,
E. Sherman White,
Richard L. Williams,
George E. Winslow.

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* Deceased.

OFFICERS, 1899.

President: Walter M. Meserole.
Vice-President: Henry B. Seaman.
Secretary: Andrew J. Provost, Jr.
Treasurer: Calvin W. Rice.

BOARD OF DIRECTORS.

Walter M. Meserole,
Henry B. Seaman,
Andrew J. Provost, Jr.,
Calvin W. Rice,
Nelson P. Lewis.

COMMITTEES.

Membership: Francis Blossom, F. L. Bartlett, R. T. Betts.
Entertainment: G. W. Tillson, H. S. Demarest, D. F. Carver.
Library: Joseph Strachan, J. C. Locke, A. J. Provost, Jr., Joseph W. Roe, D. D. Jackson.

SPECIAL COMMITTEES.

Excursions: J. C. Meem, E. C. Shaler, C. L. Hastings.
Publication: Joseph Strachan, W. S. Tuttle, W. V. Cranford, John H. Myers, Jr., C. L. Hastings.

OFFICERS, 1900.

President: George W. Tillson.
Vice-President: Henry B. Seaman.
Secretary: Andrew J. Provost, Jr.
Treasurer: Calvin W. Rice.

BOARD OF DIRECTORS.

George W. Tillson,
Henry B. Seaman,
Andrew J. Provost, Jr.,
Calvin W. Rice,
Walter M. Meserole.

STANDING COMMITTEES.

Entertainment: W. S. Tuttle, Geo. F. Rowell, H. S. Demarest.
Membership: W. T. Bruorton, F. G. Cudworth, E. C. Shaler.
Library: Joseph Strachan, J. C. Locke, A. J. Provost, Jr.

SPECIAL COMMITEES.

Excursions: D. F. Carver, J. C. Meem, R. N. Wheeler.
Publication: J. W. Roe, G. F. Rowell, C. D. Pollock, F. J. Conlon, W. M. Meserole.

BROOKLYN ENGINEERS' CLUB.

ORGANIZED OCTOBER 9TH, 1896.

HONORARY MEMBER.

Name.	Address.	Date of Election.
WHITE, ALFRED T.	40 Remsen St., Brooklyn, New York City	May 12, 1898

MEMBERS.

Name.	Address.	Date of Election.
BALSTON, OSCAR F.	Civil Engineer, 103 Decatur St., Brooklyn, New York City	Nov. 6, 1896
BARKER, HERBERT J.	Dept. of Highways, Brooklyn, New York City	Nov. 6, 1896
BARTLETT, FRANK R.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Jan. 7, 1897
BARTLETT, FRED. L.	Civil Engineer and City Surveyor, 191 Montague St., Brooklyn, New York City	Nov. 6, 1896
BARTLETT, HOMER L.	Civil Engineer and City Surveyor, Broadway and Gates Ave., Brooklyn, New York City	Nov. 6, 1896
BEACH, ROBERT J.	Civil Engineer, 191 Montague St., Brooklyn, New York City	Feb. 4, 1897
BEERS, W. L.	Contracting Civil Engineer, 258 Prospect Pl., Brooklyn, New York City	Nov. 6, 1896
BERGER, BERNT	Civil Engineer, 35 Broadway, Manhattan, New York City	April 1, 1897
BETTS, R. T.	Engineer Inspector, Dept. of Docks, Brooklyn, New York City	Nov. 6, 1896
BLOSSOM, FRANCIS	Sanderson and Porter, 31 Nassau St., Manhattan, New York City	Nov. 6, 1896
BRACKENRIDGE, J. C.	Chief Engineer, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Nov. 6, 1896
BRAINE, BANCROFT G.	Mechanical Engineer, 67 First Pl., Brooklyn, New York City	April 1, 1897

Name.	Address.	Date of Election.
Braine, Lawrence F.	General Manager, Continuous Rail Joint Co., 912 Prudential Building, Newark, N. J.	Jan. 12, 1899
Broadhurst, Wm. H.	Chemist, Dept. of Highways, Brooklyn, New York City	March 4, 1897
Brower, David	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Nov. 6, 1896
Brown, Robert P.	Assistant Chief Engineer, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	May 6, 1897
Bruorton, William T.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Oct. 9, 1896
Burke, Edmund J.	Assistant Superintendent, Motor Dept. Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Oct. 9, 1896
Butler, Noble C., Jr.	Mechanical Engineer, Worthington Hydraulic Works, P. O. Box 14, Brooklyn, New York City	Jan. 11, 1900
Byrne, Harry	Electrical Inspector, Dept. Public Buildings, Lighting and Supplies, Municipal Building, Brooklyn, New York City	Feb. 9, 1899
Caldwell, Andrew J.	General Manager, Worthington Hydraulic Works, Brooklyn, New York City	Oct. 9, 1896
Carpenter, Frederick W.	Assistant Engineer, Dept. Highways, Municipal Building, Brooklyn, New York City	Oct. 12, 1899
Carver, D. Frederick	Assistant Engineer, Track Dept., Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Nov. 6, 1896
Cattell, William A.	Civil Engineer, 192 Broadway, New York City	June 24, 1897
Chase, Richard D.	15 Monroe Pl., Brooklyn, New York City. With Allen Hazen, Consulting Engineer, 220 Broadway, New York City	Jan. 7, 1897
Clayton, Bertram T.	Engineer, Dept. of Finance, Brooklyn, New York City	Jan. 7, 1897

Name.	Address.	Date of Election.
Clift, Charles W.	Chief Engineer, Mount Prospect Pumping Station, 353 Park Pl., Brooklyn, New York City	May 6, 1897
Colby, Safford K.	Pittsburgh Reduction Co., 26 Cortlandt St., Manhattan, New York City	Jan. 7, 1897
Conklin, Leander H.	Superintendent Electrical Department, Flatbush Gas Co., 273 Clarkson St., Brooklyn, New York City	April 13, 1899
Conlon, Frank J.	Architect, 33 Rochester Ave., Brooklyn, New York City	Oct. 9, 1896
Conn, Frank W.	Superintendent New York and New Jersey Telephone Co., 81 Willoughby St., Brooklyn, New York City	April 13, 1899
Covell, Henry N.	Superintendent, Lidgerwood Mfg. Co., Brooklyn, New York City	Feb. 4, 1897
Cowperthwait, Allan	Chief Draughtsman, A. B. See Mfg. Co., 116 Front St., Brooklyn, New York City	Nov. 9, 1899
Craven, Macdonough	Sanitary Engineer, Syndicate Bldg., New York City	Jan. 7, 1897
Crowell, Robert R.	1003 Dean St., Brooklyn, New York City	April 14, 1898
Cudworth, Frank G.	Naughton & Co., Genl. Contractors, 128 W. 42d St., Manhattan, New York City	Feb. 4, 1897
Curnow, George T.	Dept. of Assessment, Brooklyn, New York City	April 1, 1897
Drake, Frederick A.	Dept. of Highways, Brooklyn, New York City	Oct. 9, 1896
Drew, John A.	Engineer and Sales Manager, Worthington Hydraulic Works, 86 Liberty St., Manhattan, New York City	Feb. 4, 1897
Drewett, William A.	Superintendent, Davidson Steam-Pump Works, Brooklyn, New York City	Feb. 4, 1897
Duryea, Edwin, Jr.	160 Cumberland St, Brooklyn, New York City	Oct. 13, 1898
Dwyer, John H.	Assistant Engineer, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Nov. 6, 1896

Name.	Address.	Date of Election.
EDWARDS, SIDNEY	Instructor Manual Training High School, Brooklyn, New York City	May 11, 1899
EVANS, FRANK L.	Electrical Dept. H. W. Johns Mfg. Co., 39th St., Brooklyn, New York City	Oct. 12, 1899
FORD, WILLIAM G.	Civil and Hydrographic Engineer, 191 Montague St., Brooklyn, New York City	Oct. 9, 1896
FORT, EDWIN J.	Assistant Engineer, Dept. of Highways, Brooklyn, New York City	Nov. 6, 1896
FLINN, THOMAS C.	Superintendent, Kennedy Valve Mfg. Co., 57 Beekman St., New York City	Jan. 7, 1897
FRENCH, ALFRED W.	Assistant Superintendent National Lead Co., Atlantic Branch, Brooklyn, New York City	April 13, 1899
FULLER, GEORGE A.	Kings Co. Elec. Light and Power Co., 187 Montague St., Brooklyn, New York City	Oct. 13, 1898
GERHARD, WILLIAM PAUL.	Consulting Engineer for Sanitary Works, 36 Union Sq., Manhattan, New York City	June 24, 1897
GOODELL, JOHN M.	Chief Editor, "The Engineering Record," 100 William St., Manhattan, New York City	Feb. 9, 1899
GRANGER, ABBOTT D.	Contracting Engineer, Burhorn and Granger, 95–97 Liberty St., Manhattan, New York City	Feb. 4, 1897
GRIFFIN, ARTHUR J.	45 Lefferts Place, Brooklyn, New York City	Nov. 6, 1896
GRIFFIN, THOMAS S.	Dept. of Docks, Brooklyn, New York City	Nov. 6, 1896
GRIFFITH, VINCENT C.	Architect, 96 Fifth Ave., Manhattan, New York City	Jan. 7, 1897
GRIFFITH, WALTER R.	Architect, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City	Nov. 6, 1896
HAMMOND, GEORGE T.	156 Berkeley Place, Brooklyn, New York City	Oct. 9, 1896
HAMMOND, JOHN F.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Jan. 7, 1897

Name.	Address.	Date of Election.
HANCOCK, FREDERICK W.	First Assistant Engineer, Ridgewood Pumping Station, Brooklyn, New York City	Feb. 4, 1897
HAVILL, HAROLD H.	Engineer, 26th Ward Sewage Purification Works, No. 67 Miller Ave., Brooklyn, New York City.	June 24, 1897
HAYES, HARRY EDGAR	Electrical Engineer, American Tel. and Tel. Co., 15 Dey St., Manhattan, New York City	May 6, 1897
HODGSON, JOSEPH E.	Eastchester Electric Co., Mt. Vernon, N. Y.	Oct. 13, 1898
IVES, ARTHUR STANLEY	Civil Engineer, 33 Sidney Pl., Brooklyn, New York City	Nov. 6, 1896
JACKSON, DANIEL D.	Chemist, Dept. Water Supply, Brooklyn, New York City, 96 Prospect Pl., Brooklyn, New York City	Oct. 13, 1898
JACOBSEN, PETER C.	Inspector, Driven Wells, Dept. of Water Supply, Brooklyn, New York City	Nov. 4, 1897
KENNEDY, DANIEL	President and General Manager, Kennedy Valve Mfg. Co., 57 Beekman St., Manhattan, New York City	May 6, 1897
KIRBY, I. HENRY	Dept. Water Supply, Ridgewood Engine House, Atlantic Ave. and Logan St., Brooklyn, New York City	Oct. 12, 1899
LANDIS, HENRY K.	Associate Editor, "Progressive Age," 280 Broadway, Manhattan, New York City	Jan. 12, 1899
LANGLOTZ, CHARLES	Chief Engineer, Lowell M. Palmer and Brooklyn Cooperage Cos., North 7th St. and Kent Ave., Brooklyn, New York City	April 1, 1897
LANGTHORN, JACOB S.	Asst. Engineer, Dept. of Bridges, 179 Washington St., Brooklyn, New York City	Oct. 9, 1896
LEGARÉ, BAILIE PEYTON	Room 516, 71 B'dway, Manhattan New York City	April 14, 1898
LEWIS, NELSON P.	Engineer, Dept. of Highways, Brooklyn, New York City	June 24, 1897
LOCKE, J. CALVIN	Dept. of Health, 40 Clinton St., Brooklyn, New York City	Nov. 6, 1896

Name.	Address.	Date of Election.
MALTBY, EDWARD L.	Worthington Hydraulic Works, Brooklyn, New York City	Oct. 9, 1896
MARTIN, CHARLES B	Electrical Engineer, N. Y. and B. Bridge, 179 Washington St., Brooklyn, New York City	May 6, 1897
MARTIN, KINGSLEY L.	Assistant Engineer, New East River Bridge, Brooklyn, New York City	Jan. 7, 1897
MCCARTHY, JAMES G.	Electrical Engineer, 261 Bainbridge St., Brooklyn, New York City	April 13, 1899
MEEM, JAMES COWAN	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Oct. 9, 1896
MESEROLE, WALTER M.	Civil Engineer and Surveyor, 191 Montague St., Brooklyn, New York City	Oct. 9, 1896
MILNE, PETER	Civil and Hydraulic Engineer, 14 John St., Manhattan, New York City	Nov. 6, 1896
MIDDLETON, JOHN	Civil Engineer and City Surveyor, 2789 Atlantic Ave., Brooklyn, New York City	Jan. 7, 1897
MURPHY, ALEXANDER D.	Assistant Engineer to Samuel H. McElroy, 26 Court St., Brooklyn, New York City	Oct. 12, 1899
MYERS, JOHN H., JR.	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	June 24, 1897
NOWACZEK, FRANK O.	Dept. of Assessment, Brooklyn, New York City	Nov. 6, 1896
OAKES, FRANK J.	Mechanical Engineer, with Henry R. Worthington, P. O. Box 14, Brooklyn, New York City	May 6, 1897
PACKE, EDWARD H.	Engineer, M. W. Track Dept., Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Jan. 7, 1897
PARK, JAMES H.	Engineer, Brooklyn Dept. Sanborn-Perris Map Co., 164 Montague St., Brooklyn, New York City	June 24, 1897
PERRY, ARTHUR IRVING	Assistant Engineer, Dept. of Highways, Brooklyn, New York City	Nov. 6, 1896

Name.	Address.	Date of Election.
PERRY, FRANCIS W.	Dept. Highways, Municipal Building, Brooklyn, New York City	Oct. 12, 1899
PICKETT, JOHN A.	Engineer, Alcatraz Co., 3 West 29th St., Manhattan, New York City	Oct. 7, 1897
POLLOCK, CLARENCE D.	Assistant Engineer, Dept. of Highways, Brooklyn, New York City.	Oct. 9, 1896
PROVOST, ANDREW J., Jr.	Assistant Engineer, Dept. of Finance, 54 Stewart Bld., Manhattan, New York City	Oct. 9, 1896
RICE, CALVIN W.	Electrical Engineer, 55 Duane St., Manhattan, New York City	April 14, 1898
ROACH, WILLIAM E.	Assistant Engineer, Dept. Finance, 54 Stewart Building, Manhattan, New York City	Jan. 11, 1900
ROBERTS, WINFRED H.	Inspector, Dept. Finance, 54 Stewart Building, Manhattan, New York City	April 13, 1899
ROE, JOSEPH W.	Worthington Hydraulic Works, P. O. Box 14, Brooklyn, New York City	Oct. 13, 1898
ROWELL, GEORGE F.	Editorial Staff, "The Engineering Record," 100 William St., Manhattan, New York City	Nov. 6, 1896
SCHERMERHORN, RICHARD, Jr.	C. W. Hunt Co., West New Brighton, Richmond, New York City	Jan. 12, 1899
SCHMITZ, FRANK C.	Continuous Rail Joint Co., 912 Prudential Bld., Newark, N. J.	Jan. 11, 1900
SEAMAN, HENRY B.	Consulting Engineer, 40 Wall St., Manhattan, New York City	Jan. 6, 1898
SHALER, EDGAR C.	Chief Draughtsman, Brooklyn Heights R. R. Co., 168 Montague St., Brooklyn, New York City.	April 14, 1898
SILLMAN, WILLIAM	Chief Engineer, H. W. Johns Mfg. Co., 39th St., Brooklyn, New York City	Jan. 11, 1900
SLANEY, HENRY C.	Brooklyn Union Gas Co., Kent and Washington Aves., Brooklyn, New York City	May 12, 1898
SOUTHARD, GEORGE C.	Civil Engineer, Lehigh Gap, Pa.	Jan. 7, 1897
STRACHAN, JOSEPH	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Oct. 9, 1896

Name.	Address.	Date of Election.
STRACHAN, ROBERT C.	Engineer in Charge, Willis Ave. Bridge, Manhattan, 373 Tompkins Ave., Brooklyn, New York City	Jan. 12, 1899
SULLIVAN, EDWARD	Electrical Inspector, Dept. Public Buildings, Lighting and Supplies, Municipal Bld., Brooklyn, New York City	Feb. 9, 1899
SWAIN, HENRY S.	878 Driggs Ave., Brooklyn, New York City	June 24, 1897
SWEZEY, EDWIN C.	Civil Engineer and City Surveyor, Third Ave. and 39th St., Brooklyn, New York City	Nov. 6, 1896
TILLSON, GEORGE W.	Assistant Engineer, Dept. of Highways, Brooklyn, New York City.	Oct. 9, 1896
TOOKER, FRANK W.	Assistant to Chas. W. Leavitt, Jr., 15 Cortlandt St., Manhattan, New York City	Oct. 12, 1899
TORRANCE, KENNETH	Chief Engineer, Ridgewood Pumping Station, Brooklyn, New York City	Nov. 6, 1896
TROUT, CHARLES E.	Pier A, North River, Manhattan, New York City	Oct. 12, 1899
TUTTLE, ARTHUR S.	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Oct. 9, 1896
TUTTLE, WILLARD S.	Superintendent, Tuttle and Bailey Mfg. Co., 83 North 10th St., Brooklyn, New York City	May 6, 1897
TYLER, WALTER L.	A. B. See Mfg. Co., 116 Front St., Brooklyn, New York City	Jan. 11, 1900
UPRIGHT, JAMES B.	Superintendent, American Mfg. Co., Noble St. and East River, Brooklyn, New York City	April 1, 1897
VAIL, FREDERIC N.	Superintendent, Alcatraz Asphalt Co., 3 West 29th St., Manhattan, New York City	Jan. 7, 1897
VAN BUSKIRK, CLARENCE R.	Assistant Engineer, Dept. of Highways, Brooklyn, New York City	Jan. 7, 1897
*VAN DER VEER, JOHN H.	Superintendent, Shops, Brooklyn, Heights R. R. Co., 168 Montague St., Brooklyn, New York City	Nov. 6, 1896

* Died December 2, 1899.

Name.	Address.	Date of Election.
WAGNER, BERNARD M.	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Oct. 9, 1896
WALKER, FREDERICK W.	Westinghouse, Church, Kerr & Co., 26 Cortlandt St., Manhattan, New York City	May 6, 1897
WATERMAN, MARCUS B.	Assistant Electrician, Am. Tel. and Elec. Subway Co., 55 Duane St., Manhattan, New York City	Jan. 11, 1900
WHEELER, RALPH N.	Assistant Engineer, Dept. of Water Supply, Brooklyn, New York City	Jan. 12, 1899
WHIPPLE, GEORGE C.	Biologist and Director of Mt. Prospect Laboratory, Dept. of Water Supply, Brooklyn, Flatbush Ave. and Eastern Parkway, Brooklyn, New York City.	Oct. 13, 1898
WHITE, E. SHERMAN	Engineer, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City	Nov. 6, 1896
WILKINS, I. CHESTER G.	Whitehall, N. Y.	Jan. 7, 1897
WILLIAMS, CHAUNCEY G	Assistant Engineer, New East River Bridge, 84 Broadway, Brooklyn, New York City	Oct. 13, 1898
WILLIAMS, RICHARD L.	Civil Engineer and City Surveyor, 204 Montague St., Brooklyn, New York City	Nov. 6, 1896
WILLS, J. LAINSON	Chemist, National Brewing Academy and Chemical Industry, 39 South William St., Manhattan, New York City	Jan. 6, 1898
WINSLOW, GEORGE E	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	Nov. 6, 1896
WOOD, NOBLE W.	Hydraulic Works, P. O. Box 14, Brooklyn, New York City	May 6, 1897
WOODWARD, FREDERICK S.	Assistant Superintendent, Overhead Construction, Edison Electric Illuminating Co., 360 Pearl St., Brooklyn, New York City	June 24, 1897
WREAKS, HUGH T.	Electrical Engineer, 91 Clinton St., Brooklyn, New York City.	Apr. 14, 1898

Name.	Address.	Date of Election.
* Wundram, George W.	Architect and Engineer, Dept. of Water Supply, Brooklyn, New York City	Jan. 7, 1897
Wynkoop, Hubert S.	Electrical Engineer, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City.	Feb. 4, 1897

ASSOCIATE MEMBERS.

Baillie, Ellis H.	Secretary, Wilson & Baillie Mfg. Co., 85 Ninth St., Brooklyn, New York City, N. Y.	June 24, 1897
Bates, Frank C.	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	June 24, 1897
Caldwell, John R	Worthington Hydraulic Works, P. O. Box 14, Brooklyn, New York City	Oct. 12, 1899
Coester, Emil	Draughtsman, Dept. of Sewers, Brooklyn, New York City	Jan. 7, 1897
Cranford, Frederick L.	Cranford & Co., 215 Montague St., Brooklyn, New York City	Apr. 14, 1898
Cranford, Walter V.	Cranford & Co., 215 Montague St., Brooklyn, New York City	Apr. 14, 1898
Cregin, Charles A.	Contractor, 40 Court St., Brooklyn, New York City	June 24, 1897
Crosby, Eugene	Dept. of Assessment, Brooklyn, New York City	June 24, 1897
Demarest, Henry S.	International Steam Pump Co., 26 B'way, New York City	June 24, 1897
Driggs, Clifford V.	Superintendent, Street Construction, etc., Edison Elec. Ill. Co., 360 Pearl St., Brooklyn, New York City	March 9, 1899
Florandin, Charles H.	C. and C. Electric Co., 143 Liberty St., Manhattan, New York City.	Jan. 12, 1899
Gellatly, Edward S.	Patterson-Sargent Co., 42 Hudson St., Manhattan, New York City	
Grinden, William J.	Secretary, J. H. Williams & Co., Richards and Bowne Sts., Brooklyn, New York City	June 24, 1897

* Died November 9, 1899.

Name.	Address.	Date of Election.
HANN, JOHN	General Contractor, 189 Montague St., Brooklyn, New York City	Oct. 12, 1899
HASTINGS, CHARLES L	Patterson-Sargent Co., Boston, Mass.	May 6, 1897
KEARNS, WILLIAM F	Dept. Highways, Municipal Building, Brooklyn, New York City	Jan. 11, 1900
KELLY, JOHN A	62 Beard St., Brooklyn, New York City	March 4, 1897
KOLLER, WINFIELD R	Worthington Hydraulic Works, Brooklyn, New York City	April 1, 1897
MAGRATH, JAMES W	Assistant Engineer, Dept. of Sewers, Brooklyn, New York City	June 24, 1897
MARKEY, WILLIAM A	Leveler, Dept. of Sewers, Brooklyn, New York City	June 24, 1897
SOUTHWORTH, FRANK G	Traffic Chief, N. Y. & N. J. Tel. Co., 81 Willoughby St., Brooklyn, New York City	Jan. 6, 1898
SQUIRES, WILLIAM H	With Wm. Jessop & Sons, Limited, 94 Clinton Ave., Brooklyn, New York City	April 14, 1898
THOMAS, THOMAS H	President, Eastern Bermudez Asphalt Paving Co., 11 Broadway, Manhattan, New York City	Jan. 12, 1899
TICE, GEORGE, Jr	Draughtsman, Dept. of Buildings, Lighting and Supplies, Brooklyn, New York City	Jan. 7, 1897
WEIDERMAN, GEORGE	Electrical Engineer, 309 Flatbush Ave., Brooklyn, New York City.	Nov. 9, 1899

NON-RESIDENT MEMBERS.

BARRON, FREDERICK A	General Electric Co., Schenectady, N. Y.	March 4, 1897
CRANE, ALBERT S	Asst. Chief Engineer, Am. Lake Superior Power Co., Sault Ste. Marie, Mich.	Oct. 9, 1896
DARBEC, WILLIAM	Local Manager, Connecticut Lighting and Power Co., South Norwalk, Conn	Jan. 6, 1898

Name.	Address	Date of Election.
Foster, Ernest H.	153 Queen Victoria St., London, Eng.	Jan. 7, 1897
Locke, William W.	Metropolitan Water Board, South Framingham, Mass.	Jan. 7, 1897
Pierce, Frederick E.	New Jersey Zinc Co., Passaic Ave., Newark, N. J.	Oct. 9, 1896
Tenney, Willis R.	Asst. Engineer, Dept. of Havana, Tacon 3, Havana, Cuba	Jan. 7, 1897

PROCEEDINGS OF THE ANNUAL MEETING

HELD AT

THE ARGYLE, DECEMBER 14th, 1899.

President Walter M. Meserole called the meeting to order at 9 P. M. The reading of the minutes of the last meeting, November 9th, was dispensed with. The Secretary reported the announcement by the President of the appointment of a Publication Committee as follows: Joseph W. Roe, George F. Rowell, C. D. Pollock, F. J. Conlon and W. M. Meserole. Said Committee to have charge of the publication of the Club for the present year.

The Secretary transmitted a resolution of the Board of Directors recommending the reinstatement of H. S. Swain to full corporate membership, which action was adopted.

The Secretary reported the loss by death since the last meeting of two corporate members, George W. Wundram and John H. Van der Veer. Upon motion the President was asked to appoint committees to draft resolutions recognizing the great loss which the Club has sustained through the deaths of George W. Wundram and of John H. Van der Veer. The President appointed Messrs. Joseph Strachan and R. L. Williams to draft resolutions on the death of Mr. Wundram; Messrs. Carver and Bruorton on the death of Mr. Van der Veer. These committees reported later the following resolutions:

By Mr. Strachan:

Whereas, The Brooklyn Engineers' Club has, by the death on November 9th of George W. Wundram, lost a valued member; therefore, be it

Resolved, That the Club on this, the occasion of its Annual Meeting, expresses its appreciation of the loss it has sustained, and of its sympathy with the family of our deceased member; and be it further

Resolved, That these resolutions be spread upon the minutes of the Club, and that a copy of the same be sent to the family of the deceased.

Which was unanimously adopted.

By Mr. Carver:

Whereas, It has pleased Almighty God in his inscrutable wisdom to remove from amongst us John H. Van der Veer, our loved companion and associate, and

Whereas, We of this Club, who knew him to be well worthy of our high esteem and deep respect, desire to express our appreciation of the great loss which we have sustained, and to offer to those who were his best beloved our sincere condolence; therefore be it

Resolved, That this memorial be spread upon the minutes of the Club, and that a copy of the same be sent to the family of the deceased.

Which was unanimously adopted.

The Secretary then presented the annual report of the Board of Directors.

BROOKLYN, N. Y., DECEMBER 12TH, 1899.

BROOKLYN ENGINEERS' CLUB.

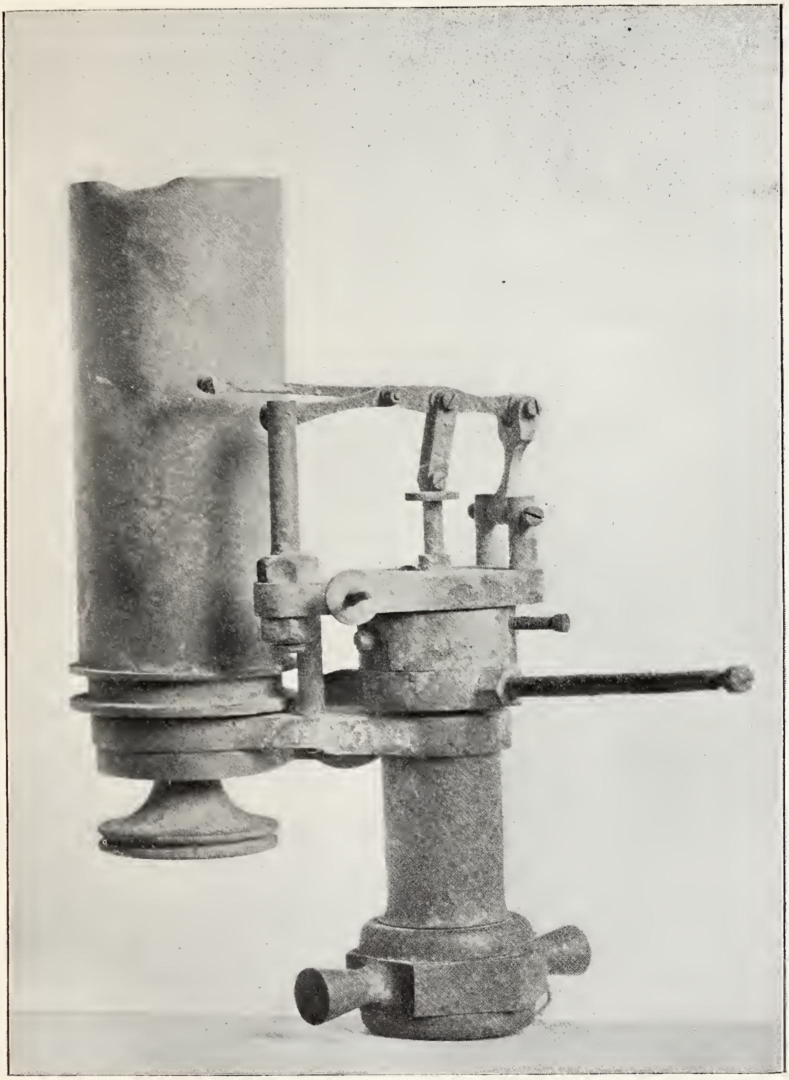
Gentlemen,—The Board of Directors presents herewith its annual report.

The past year, being the third of the Club's corporate existence, has been one of substantial progress along lines heretofore successfully established. The work done, which is constantly increasing, has been performed in a manner highly pleasing to your Board, and should meet the approval which it justifies.

Thirty-five meetings of various natures have been held during the year. The opportunities offered for professional and social intercourse are, it is believed, second to those of no other similar organization in the country. These have been made use of, as shown by the attendance, to a degree highly satisfactory. The co-operative spirit shown by the members on all matters argues well for the future of the Club and the successful adjustment of matters involving a community of interest.

The only radical departure from the lines laid down by the original committee in its preparation of the Constitution has been an amendment adopted during the past year which created a non-resident grade of membership. In creating this grade, the geographical limits of the Club's active membership were extended so as to include all of the territory covered by the present City of New York. Members now residing and doing business beyond those limits are classed in the non-resident grade. This action has extended the usefulness of the Club and continued the interest of former active members who have removed beyond the limits of its work.

Committee Work.—The Board points with pride to the second volume of the Club's proceedings, which appeared during the year, from the hands of the Publication Committee. The publication was eminently successful as a contribution to technical literature, and from a financial standpoint. Too much credit cannot be given to the Committee for



INDICATOR FROM THE *Viscaya*.

SPANISH WAR RELIC.

At the meeting of January 12th, 1899, formal presentation was made to the Club by Mr. W. A. Drewett, M. B. E. C., of a steam indicator taken from the engines of the Spanish armored cruiser *Viscaya* shortly after her destruction by the United States Navy at Santiago, Cuba, on July 3, 1898.

The relic has been mounted and is displayed in the Library of the Club in a manner intended to show its full interest and value. A cut of the indicator is herewith published accompanied by a *fac-simile* of the letter of gift to Mr. Drewett from Mr. C. R. Roelker, Chief Engineer, U. S. N., explaining the authenticity of the relic and the manner in which it came into his possession.

NAVY DEPARTMENT,
BOARD OF INSPECTION AND SURVEY,
WASHINGTON,

December 30/98

Wm. A. Drewett Esqr.

Dear Sir:

Mr. Baird tells me that you would like to have "some account of the facts concerning the finding of the "Indicator" taken from "Viscaya", which he presented to the Club of which you are a member. It is a short story.

After the destruction of Cervera's fleet the naval vessels stationed in the vicinity of Santiago made occasional trips to the scene of the wrecks, and boat parties were allowed to visit them. As the "Viscaya" was hopelessly destroyed by shot, fire and internal explosions permission was given to officers and men of these visiting parties to secure articles of no particular intrinsic value as souvenirs of the glorious victory of the 3d July. The indicator was found attached to one of the cylinders by my first Assistant on the U.S.S. Newark, Passed Assistant Engineer Albert J. Mickley U.S.N. who presented it to me. After my return from the West Indies I gave it to my good friend Chief Engineer Geo. W. Baird U.S.N. who thought that it would be more appropriate to deposit it with a public institution where its significance would be duly appreciated by a wider circle. I am very glad to hear that it has been placed in such good hands.

Yours respectfully
C. R. Roelker
Chief Engr. U.S.N.

its work in editing the various papers, for the character of the volume and for the painstaking manner in which, through its report, the Committee has made available for future committees the results of its experience with various details of the work.

The Library Committee has continued successfully throughout the year, the management of the library and the presentation of informal Thursday night discussions, along the lines developed by previous committees. The amount of work performed by the Committee has entailed large personal sacrifices on the part of its members. Appreciation of the services rendered may be gracefully shown in an increased use of the library which is now rendered more accessible and generally useful through the card index recently installed by the Committee.

The Entertainment Committee has furnished the papers read before the regular meetings, and generally conducted all the arrangements for these meetings, as well as for the June dinner to the ladies, at the Clarendon Inn, which was very successfully repeated. The detailed report of this Committee is referred to your considerate attention.

Under the auspices of the Excursion Committee, a number of excursions, both local and out of town, have been arranged and carried out during the past year. These have been well attended, and may be considered a strong factor in the work which the Club is doing. Proper acknowledgment is made in the report of this Committee to individuals, organizations and corporations for courtesies rendered in connection with these trips.

The Membership Committee has investigated promptly and with good judgment the qualifications of applicants for membership referred to them. The report of this Committee and the recommendations contained therein, are referred to your attention.

It is with deep regret that the Board reports the loss by death of two Corporate members, George W. Wundram on November 9th, and John H. Van der Veer on December 2d. Mr. Van der Veer was a charter member of the Club, and Mr. Wundram's admission dates from the first meeting after the Club's incorporation. It is intended that memoirs of these members appear in the forthcoming annual publication.

An interesting event during the year was the formal presentation at the January meeting by which, through Mr. W. A. Drewett, the Club became the recipient of a valuable and interesting relic of the Spanish war. The relic has been suitably mounted and inscribed under the direction of the Library Committee and assigned to a place in the Club library.

As provided by the Constitution, the Board of Directors has audited the accounts of the Secretary and Treasurer, and hereby

reports having found the same to be correct. The result of this audit is herewith given:

RECEIPTS.

From dues 129 members, all classes	$1 144 00	
" initiation fees	140 00	
" Annual Publication	1 061 59	
		$2 345 59
Interest on daily balances		17 35
		$2 362 94

EXPENDITURES.

Brooklyn Library on account contract	$450 00	
Postage and stationery	143 54	
Janitor's services	24 00	
Typewriting and stenography	80 00	
Meetings and entertainments	199 61	
Publication Committee, expenses	868 71	
Excursion Committee, expenses	32 30	
Secretary's salary	300 00	
Library furniture	67 80	
Telephone	35 23	
		$2 201 19
Making net revenue for the year		$161 75
Balance November 30th, 1898		622 49
Balance deposited with Franklin Trust Company at this date		$784 24

It should be stated that the sum of $29.00 drawn from the treasury on account of collation charges, under a new arrangement, is returnable to the general fund upon collection. The balance and net revenue for the year are therefore in reality $29.00 in excess of the figures herein stated.

The Board desires to further express its approval of the very excellent work performed by the officers and various committees, and recommends to your careful study their reports hereto appended.

(Signed) WALTER M. MESEROLE,
NELSON P. LEWIS,
A. J. PROVOST, JR.,
C. W. RICE,
HENRY B. SEAMAN,
Board of Directors.

The Secretary then read the following reports:

Office of Secretary, 191 Montague Street,
Brooklyn, N. Y., December 5th, 1899.

The Board of Directors,
Brooklyn Engineers' Club.

Gentlemen,—The Secretary has the honor to submit the following as his annual report:

The roll of the Club, at the date of the last annual report (November 30th, 1898), contained 145 names, classified as follows:

Corporate members	125
Associate members	19
Honorary member	1
Total	145

There have been added during the past year by election 22 Corporate members and 6 Associate members. There have been 7 Corporate members transferred to the Non-resident grade under the provisions of the Constitution as amended on April 13th last. There have been lost during the past year by death, 2 Corporate members; by resignation, 5 Corporate members and 2 Associate members; dropped from the rolls for non-payment of dues, 5 Corporate members.

Making the present total membership:

Corporate members	128
Associate members	23
Non-resident members	7
Honorary member.	1
Total	159

There have been held during the year 8 regular meetings, with a total attendance of 363.

The receipts of the Club during the fiscal year ending December 14th have been as follows:

From dues and initiation fees	$1 284 00
From Annual Publication	1 061 59
	$2 345 59

These funds have been paid over to the Treasurer for deposit to the credit of the Club.

The funds collected for collation purposes have constituted a separate fund which has been expended as directed by the Entertainment Committee.

Respectfully submitted,

(Signed) A. J. Provost, Jr.,
Secretary.

TREASURER'S REPORT.

From December 1st, 1898, to December 1st, 1899.

BROOKLYN, N. Y., DECEMBER 14TH, 1899.

Calvin W. Rice, Treasurer, in account with Brooklyn Engineers' Club.

DR.

Balance from December 1st, 1898	$622 49	
Received from the Secretary December 1st, 1898, to December 1st, 1899	2 345 59	
Interest accrued	17 35	
		$2 985 43

CR.

Payments from December 1st, 1898, to December 1st, 1899, on warrants from the Secretary and approved by the President.	$2 201 19	
Balance to new account	784 24	
		$2 985 43
Balance on hand December 1st, 1899		784 24

(Signed) CALVIN W. RICE,
Treasurer.

BROOKLYN, N. Y., DECEMBER 5TH, 1899.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen,—Your Entertainment Committee herewith submits a report of its operations for the year ending December 31st, 1899.

The meetings have been held as during the latter part of 1898, in the rooms of the Argyle, upon the same terms as at that time. This continues to give satisfaction and your Committee is of the opinion that no better arrangements can be made as the rooms are centrally located and equipped with all conveniences for lantern slide pictures, etc.

During the year the following papers have been provided by the Committee:

Jan.: "Notes on Street Paving Materials and Their Uses," by N. P. Lewis.

Feb.: "A Half Century of Sanitation," by Wm. Paul Gerhard.

March: "Electrolysis, an Unsolved Municipal Problem," by H. S. Wynkoop.

April: "A General Discussion on Plans and Specifications." Opened by W. V. Cranford and Edwin Duryea, Jr.

May: "Aluminum," by S. K. Colby.

Oct.: "The New York Building Law in Relation to High Buildings," by R. C. Strachan.

Nov.: "Recent Developments in Gas Engineering," by H. K. Landis.

The Committee wishes to call attention to the fact that on account of unavoidable circumstances at several meetings it became necessary to present different papers from those originally planned. On account of the resources of the Club the Committee was able to do this, even at short notice, without lowering the standard of the papers. This, however, is dangerous and shows the importance of always having at least one paper in advance in the hands of the Entertainment Committee. By so doing, the labor and worry of the Committee will be very much reduced.

On the 8th of June, the Club gave its second annual dinner to the ladies at the Clarendon Inn on the Ocean Parkway. This was attended by thirty-two ladies and thirty-three gentlemen, and its success fully justified the Club in making it one of its fixed, though informal, gatherings of the year.

The balance in the collation fund on June 1st was applied on the dinner to the ladies, the members paying a fixed sum and the difference being made up by the Club and the aforesaid balance. For the current year a different plan has been adopted in paying for collations. The Board of Directors authorized the Committee to draw on the Treasurer for a fixed amount. At each meeting the members at the collation sign tickets which are retained by the Treasurer and a bill for the same will be sent each member in January and June of each year. This method seems to be satisfactory and will be continued unless some future developments show its unfitness.

Herewith please find statement of the fund up to and including the June meeting, when it was closed:

Balance on hand December 1st, 1898......	$91 42	
Receipts to December 1st, 1899...........	173 60	
		$265 02
Expenditures.............................	$263 45	
Paid into Club Treasury..................	1 57	
		$265 02

The stereopticon has been used quite extensively during the year and the wisdom of its purchase plainly demonstrated. It costs nothing for use, as it is connected with the electric fixtures in the hall and operated at meetings by a member of the Club, Mr. F. A. Drake, who deserves the thanks of the Club for his services.

During the summer an unsuccessful effort was made to have papers in the hands of the Committee several weeks previous to their presentation to the Society. The importance of this has been referred to before, and the Committee would recommend that further effort be made by the incoming Committee to accomplish the same result, as its importance can hardly be over-estimated.

In closing up its work of the last two years the Committee wishes

to express its obligation to all members who have contributed papers, as well as to the Board of Directors for their hearty co-operation.

All of which is respectfully submitted,

(Signed) GEO. W. TILLSON,
H. S. DEMAREST,
D. F. CARVER,
Entertainment Committee.

DECEMBER 7TH, 1899.

The Board of Directors,
BROOKLYN ENGINEERS' CLUB.

Gentlemen,—The Library Committee reports its work for the year ending December 14th to have been as follows:

General charge of rooms and library secured to the Club by renewal of contract made with the Brooklyn Library by your Board in the early part of the year.

The cataloguing of the works in the library has made very substantial progress, and it is hoped that, by the time of reading of this report, the card index, which is now in course of preparation by the Macey Company, with whom a contract has been made to typewrite the titles on the cards and suitably class them for purposes of cross-indexing, will be completed and in the cabinet ready for use by the members of the Club.

The system of entering new books in the accession book, and listing desirable ones for purchase by the Brooklyn Library, as described in the last annual report of this Committee, has been continued.

The additions to the library during the year have been as follows:

By Purchase:		
Standard Reference Works......	50 vols., at a cost of	$137 19
Periodicals (binding included)..	74 " " "	269 40
Total..................	124 " " "	$406 59
By Donation:		
Bound volumes..............	53 vols.	
Pamphlets (reports, etc.)......	120 " and 595 numbers of periodicals incomplete.	
Total accessions......	297 " and 595 numbers of periodicals incomplete.	

Total number of volumes in library at this day, 2 627 volumes.

In presenting herewith a statement of the donations received during the year, the Committee desires to express its thanks to the donors named:

B. G. Braine, 14 vols. and 72 numbers incomplete periodicals; F. E. Brandis, 13 vols. and 477 numbers incomplete periodi-

cals; through Brooklyn Library, 13 vols.; R. T. Betts, 9 vols.; United States Department of Agriculture, 7 vols.; United States War Department, United States Department of the Interior, and A. J. Provost, Jr., 6 vols. each; B. F. Sturtevant, 5 vols.; Wm. Paul Gerhard, D. D. Jackson, Continental Iron Works, 3 vols. each; Peter Milne, William R. Hill, Civil Engineers' Association Cornell University, Brooklyn Engineers' Club, Mayor, Louisville, Ky., New York Railroad Commissioners, and Director United States Geological Survey, 2 vols. each; S. K. Colby, Cleveland Engineers' Club, Ohio State Board of Health, H. K. Landis, N. P. Lewis, W. S. Tuttle, A. S. Tuttle, W. E. Belknap, Secretary Kansas City Department Public Works, W. R. Tenney, H. B. Seaman, Pratt Institute, J. H. Williams Company, Goheen Manufacturing Company, General Electric Company, Montauk Club, New York Engineers' Club, Massachusetts Gas and Electric Light Commissioners, Ontario Provincial Board of Health, and Baltimore Sewerage Commission, 1 vol. each; F. S. Woodward, 46 numbers incomplete periodicals; W. B. Parsons, 36 maps, Contract Plans New York Rapid Transit Commission, dated April, 1898.

Files of periodicals regularly received:

Aluminum World.
American Association for Advancement of Science.
American Architect and Building News.
American Institute of Electrical Engineers.
American Institute of Mining Engineers.
American Microscopical Journal.
American Public Health Association Journal.
American Journal of Science.
American Society of Civil Engineers, Transactions of.
American Society of Mechanical Engineers.
American Society of Municipal Improvements.
Annales des Ponts et Chaussées.
Association of Engineering Societies, Journal of.
Brooklyn Engineers' Club, Proceedings of.
Builder, The.
Building News.
Cassier's Magazine.
Chemical News.
Electrical Engineer.
Electrical World.
Electrician, The.
Engineer, The.

Engineering Magazine.
Engineering and Mining Journal.
Engineering News.
Engineering Record.
Engineering.
Franklin Institute, Journal of.
Geological Magazine.
Incorporated Association of Municipal and County Engineers.
Iowa Engineering Society, Proceedings of.
Institution of Civil Engineers, Proceedings of.
Iron and Steel Institute, Journal of.
Manufacturers' Record.
Master Car Builders' Association, Proceedings of.
Microscopical Science, Quarterly Journal of.
Municipal Engineering.
Municipal and County Engineers, Incorp. Assoc. of, Proceedings.
Naval Architects and Marine Engineers, Transactions of.
New England Water-Works Association, Journal of.
New York Meteorological Observations.
New York State Board of Health, Bulletin of.
Ohio Sanitary Bulletin.
Ohio Society of Surveyors and Civil Engineers.
Philadelphia Engineers' Club, Proceedings of.
Ponts et Chaussées, Annales des.
Popular Astronomy.
Progressive Age.
Public Improvements.
Railroad Gazette.
Sanitary Record.
Science.
Scientific American Supplement.
Scientific Literature, Monthly Record of.
Society of Engineers, Transactions of.
Société des Ingénieurs Civils, Mémoires de la.
School of Mines Quarterly.
Stevens Indicator.
St. Louis Engineers' Club, Proceedings of.
Street Railway Journal.
United States Army, Report of Chief of Engineers.
United States Weather Bureau, Report of Chief of.
Water and Gas.
Western Society of Engineers, Journal of.

Bound Volumes of Periodicals, Society Transactions, etc.:

American Association for Advancement of Science, Vols. 20–47, inclusive.

American Architect and Building News, Vols. 11–60, except Vol. 20, 1882–1898.

American Institute of Electrical Engineers, Vols. 12 and 13.

American Institute of Mining Engineers, Vols. 1–28, 1871–98.

American Journal of Science, Vols. 6–22, inclusive, except Vols. 7 and 16.

American Public Health Association Journal, Vols. 4, 7, and 15–24, inclusive, except Vols. 22 and 23.

American Society of Civil Engineers, Transactions, 1895–1899.

American Society of Mechanical Engineers, Transactions, Vols. 14–19, 1893–1898.

Annales des Ponts et Chaussées, 1895–1899, inclusive.

Association of Engineering Societies, Journal of, Vols. 15–22, inclusive, except Vol. 19.

Brooklyn Engineers' Club, Proceedings, 1897–1899.

Builder, The, Vols. 18–77, inclusive, 1860–1899.

Building News, Vols. 16–77, inclusive, 1869–1899.

Cassier's Magazine, Vols. 8–16, inclusive, 1895–1899.

Chemical News, Vols. 21–78, inclusive, 1870–1898.

Digest of Physical Tests, Vols. 1–3, 1896–1898.

Electrical Engineer, Vols. 3–26, inclusive, 1888–1898.

Electrical World, Vols. 25–32, inclusive, 1895–1898.

Electrician, The, Vols. 39 and 40, 1897–1898.

Engineer, The, Vols. 27–85, inclusive, 1869–1899.

Engineering, Vols 7–66, inclusive, 1869–1899.

Engineering Magazine, Vols. 1–17, inclusive, 1891–1899.

Engineering and Mining Journal, 1872–1898, inclusive, except 1874–75 and 1892.

Engineering News, 1878–1899, inclusive, except 1883.

Engineering Record, Vols. 31–38, inclusive, 1895–1898.

Franklin Institute, Journal of, 1828–1851, and 1873–1898, inclusive.

Good Roads, Vols. 2 and 3, 1892 and 1893.

Institution of Civil Engineers, Proceedings, Vols. 75–137, inclusive, except 119, 120, and 121.

Iron and Steel Institute, Journal of, Vols. 51–55, 1899.

Master Car-Builders' Association, Proceedings, Vol. 30, 1896.

Microscopical Science, Quarterly Journal, Vols. 20–41, except Vol. 32, 1880–1898.

Municipal Engineering, Vols. 4–16, 1893–1899.

Municipal and County Engineers, Proceedings, Vols. 22–24, 1895–1898.

Naval Architects and Marine Engineers, Transactions, Vols. 1–6, inclusive, 1893–1898.

New England Water-Works Association, Journal, Vols. 10–13.

New York Meteorological Observations, 1878, 1895–99, inclusive.
Philadelphia Engineers' Club, Proceedings, Vols. 5, 12–15.
Physical Tests, Digest of, Vols. 1–3, 1896–1898.
Ponts et Chaussées, Annales des, 1895–1899, inclusive.
Popular Astronomy, Vols. 1-6, inclusive, 1893–1898.
Railroad Gazette, Vol. 29, 1897.
Sanitary Record, Vols. 21–24, inclusive, 1898 and 1899.
Science, 1884–1899, inclusive, except 1894.
Society of Engineers, Transactions, 1894–1898, inclusive.
Société des Ingénieurs Civils, Mémoires de la, 1895–1899.
School of Mines Quarterly, Vols. 3, and 11–18, inclusive.
Street Railway Journal, Vols. 11 and 13, 1895 and 1897.
U. S. Army, Chief of Engineer's Report, 1891–1899, inclusive.
Van Nostrand's Eclectic Magazine, Vols. 1–36, inclusive.
Western Society of Engineers, Journal, Vols. 1–3, inclusive.

Attention is called to one of the tables accompanying this report, in which appears a list of bound volumes of periodical literature on the shelves. Many of these files are incomplete. Members are respectfully urged to study these lists and to do what they can toward making them complete. All donations should be made directly to the Club through the Secretary, for your Committee, while believing the present contract with the Brooklyn Library advantageous to the Club and recommending its continuance, is deeply convinced that the Club should be, at this time, accumulating books of its own. It therefore earnestly asks the members of the Club to denote toward this purpose any works in their own collections that may be available. While missing numbers of the proceedings of engineering societies are particularly desired, members should note that duplicates of these and other publications will be most acceptable, as they are valuable for exchange.

The souvenir of the Spanish War, donated to the Club through the efforts of Mr. W. A. Drewett, one of our members, which has been in the custody of this Committee, will be, it is hoped, very soon suitably cased and set up in the Library room where all can fully inspect it. A contract for a case in which to enclose it was made during the month of October, 1899, with the Nassau Show Case Company, of 52 Ellery Street, and its delivery promised on November 20th. A suitably framed card containing a description of the manner in which it came into possession of the Club will be displayed near the relic.

The informal Thursday night discussions at the Library rooms have become an established feature of the Club. During the past year they have been regularly held, interrupted only by the holiday seasons, during which it has been thought not advisable to ask a member to give his time and effort to a small attendance. The average

number in attendance during the year at these gatherings has been about 15, and as many as 25 have assembled. The general opinion of those attending seems to be that they are one of the best features of the Club, and many extremely interesting matters have been discussed, as appears from the list of subjects and speakers attached hereto.

The Committee hopes that the members generally will bear in mind that on Thursday evenings, except the second of each month and holidays, they will be sure to hear something of interest discussed at the library rooms, and should no postal notice be received, it does not at all mean that no speaker has been secured. The Committee also requests the members of the Club to communicate to it the name and address of any person not a member of the Club who could be persuaded to give one of these informal talks at the library rooms on some subject which would be of interest, as it is not the policy of the Club to limit the speakers to Club members only. It is also suggested that each member consider carefully the work he is doing as a possible subject for a Thursday night talk, and notify the Library Committee of his willingness to appear, as this would materially assist the Committee in diversifying the subjects discussed.

The topics discussed during the past year are as follows:

Jan.	19th.	"Methods of Sewer Assessments," George E. Winslow.
"	26th.	"Harrisburg, Pa., Filter Plant," R. D. Chase.
Feb.	2d.	"Brooklyn Rapid Transit Problem," W. M. Meserole.
"	16th.	"Subways and Arrangement of Contained Piping," J. C. Meem.
"	23d.	"Sewerage Plans of Brooklyn Suburbs," Henry Asserson.
Mar.	2d.	"Gas Meters," H. S. Wynkoop.
"	16th.	"Trolley Subway Construction," F. G. Cudworth.
"	23d.	"Street Car Vestibules," B. P. Legaré.
"	30th.	"New East River Bridge Foundation, N. Y. Tower," K. L. Martin.
April	6th.	"Return Tubular Boilers," A. D. Granger.
"	20th.	"Maps, Map Making and Publishing," J. H. Park.
"	27th.	"Gas Distribution," H. G. Slaney.
May	4th.	"Sanitary Conditions of Coney Island," J. C. Locke.
"	18th.	"Building Stones," G. W. Tillson.
"	25th.	"Water Filtration," C. L. Parmelee.
Oct.	19th.	"Grade Crossings," H. B. Seaman.
"	26th.	"Assessments for Local Improvements," N. P. Lewis.
Nov.	2d.	"Worthington High Duty Attachment," J. W. Roe.
"	16th.	"Works for the Improvement of River Navigation," George F. Rowell.
"	23d.	"Engineering Features Dominion Coal Co." G. A. Orrok.
Dec.	7th.	"New York Rapid Transit Plans," W. F. Smith.

Referring to the contract made by your Board with the Brooklyn Library, the Committee reports as follows:

The Brooklyn Library has received from the Club...		$450 00
and has expended upon the recommendation of the Committee:		
For new books.	$137 19	
*For periodicals and bindings	155 00	
		$292 19

Your Committee respectfully recommends that the necessary steps be taken to secure the continuance of present arrangement with the Brooklyn Library as to library privileges before expiration of present contract, February 1st, 1900.

Estimate of money needed for library purposes for 1900:

Your Committee is of the opinion that there will be needed during the coming year $200 for the purchase of new books and $200 for periodicals, classified as new, with bindings, a total of $400, which sum should be arranged for in any contract with the Brooklyn Library which your Board shall make. There should be set aside from the funds of the Club the sum of $24 for the services of janitor during the coming year, and $50 for expenses of giving notices of Thursday night meetings.

The installation of a pay station telephone in the library, while somewhat disappointing as a money-making proposition, has been valuable to members who desire to use the library, and also keep in touch with their business. It is largely on this account that the Committee advocates retaining the telephone for a more extended trial.

The Committee desires to express its appreciation of the uniform assistance and courtesies received at the hands of the Librarian of the Brooklyn Library and his staff. Also to thank your Board for the kindly interest shown in the Committee's work during the year.

Respectfully submitted,

(Signed) JOSEPH STRACHAN,
J. CALVIN LOCKE,
A. J. PROVOST, JR.,
Library Committee.

BROOKLYN, N. Y., DECEMBER 1ST, 1899.

To the Board of Directors,
BROOKLYN ENGINEERS' CLUB,

Gentlemen,—The Membership Committee herewith submits its annual report:

During the year 1899 the Committee has investigated and passed upon the applications of twenty-four (24) candidates for corporate

* Periodicals subscribed for prior to October 1st, 1895, together with bindings for same, are not included in this item.

membership, and four (4) candidates for associate membership. They are pleased to state that in every case they have been able to report favorably to your Board.

The Membership Committee favors the retention of the Special Committee provided for in Article III, Section 2, of the Constitution. In other respects the general recommendations of last year's Membership Committee are fully endorsed.

The Committee would also advise that a high standard of professional and social qualifications be applied in passing upon applications for associate membership.

Respectfully submitted,
(Signed) FRANCIS BLOSSOM,
FRED. L. BARTLETT,
A. T. BETTS,
Committee on Membership.

REPORT OF THE EXCURSION COMMITTEE OF THE BROOKLYN ENGINEERS CLUB.

Following the policy originally established by the Club of having excursions whenever practicable, the Excursion Committee has, during the past fiscal year, through the co-operation of the Club members and others, held five excursions, of which the following are brief summaries:

On January 28th, 1899, an excursion was arranged to the Power House of the Metropolitan Railway Company at Twenty-fifth Street near Lexington Avenue. A special car, provided by courtesy of the Brooklyn Heights Railroad Company (now Brooklyn Rapid Transit), left Borough Hall, Brooklyn, at 2.40 P. M., and connected with a Metropolitan Street Railway Company special car at the Manhattan end of the bridge, the latter car being furnished by courtesy of that company. The power house was reached at 3.20 P. M., after which more than two hours were spent in an inspection of the dynamos, cables, boilers and other equipment of this large and interesting plant. At 5.30 P. M., those who so desired repaired to the Café Boulevard and took dinner. The excursion was attended by about 45 members and guests.

An excursion was held on Saturday afternoon, March 25th, to the Ridgewood Pumping Station of the Brooklyn Water Works. A special car, provided through the courtesy of the Nassau Railroad Company, conveyed 35 members and guests to the station which was reached at about 3.45 P. M. After two hours spent in a careful and interesting inspection of both the new and old stations, the party repaired to the special car and were taken to Piel's where dinner was served.

On the evening of June 1st, 1899, the Club was invited by the management of the Electrical Exhibition, then at Madison Square Garden, to visit the show. Some 40 members responded to the invita-

tion and spent a most enjoyable evening. Special cars provided by the Brooklyn Rapid Transit and the Metropolitan Street Railway Companies conveyed the party from Borough Hall, in Brooklyn, to the Garden in Manhattan, which was reached at 8 P. M., thus allowing more than two hours for thoroughly inspecting the many and various branches of the instructive exhibit.

On July 8th, 1899, some 35 members of the Club were the guests of the Crocker-Wheeler Company at Ampere, N. J. A tug furnished by that company's courtesy left the foot of Montague Street at 1.30 P. M., connecting with a D. L. & W. train for Ampere at 2.25 P. M. Nearly two hours were spent in the electrical shops of this company in a most instructive and interesting inspection of their plant.

In conjunction with some of the members of the 2d Naval Battalion N. R., S. N. Y., an excursion was held on Saturday afternoon, August 26th, 1899, to the Proving Ground at Sandy Hook. Through the courtesy of the Brooklyn Rapid Transit Company a special car was provided from Borough Hall to the foot of 56th Street, New York Bay, when the party was received on board the yacht *Aileen*, under command of Lieutenant Beale of the Naval Reserve. After a delightful sail Sandy Hook was reached, when the party of over 60 spent some time in inspecting the big guns, etc. It was a source of regret to the Club that the excursion could not be held at any time other than Saturday afternoon, when all firing and testing had ceased.

The Committee wishes again to echo the thanks so warmly expressed by all who participated in the excursion at the cordial reception and special courtesies extended to them by the members of the Battalion on board the *Aileen*, and begs to express the hope that the existing pleasant relations between the Battalion and the Club may always continue.

During the year the Committee lost the services of Mr. B. P. Legaré, whose duties called him to England, and who was replaced by one of the undersigned, Mr. Shaler.

In closing, the Committee wishes to express their sincere thanks for courtesies extended by the Brooklyn Rapid Transit Company of Brooklyn, the Metropolitan Street Railway Company of Manhattan, the officers of the Ridgewood Pumping Station, the management of the Electrical Exhibition, the Crocker-Wheeler Electric Company of Ampere, N. J., and the 2d Naval Battalion N. R., S. N. Y., and adds, that since the above excursions have been made practicable only by the hearty co-operation of individual members of the Club, the Committee wishes to ask for its successors continued help in the way of suggestion or efforts in this direction.

(Signed) J. C. MEEM, *Chairman.*
E. C. SHALER,
C. L. HASTINGS,
Excursion Committee.

The above reports, on motion, were accepted and ordered filed.

The President then declared that the business before the Club was the election of officers for the ensuing year. He announced nominations made at the November meeting as follows:

For President, George W. Tillson.
For Secretary, Andrew J. Provost, Jr.
For Treasurer, Calvin W. Rice.

In the absence of any further nominations he declared a ballot in order, and appointed Messrs. Pollock and Locke tellers to canvass the vote.

A ballot was then taken. The tellers' report showed 36 ballots cast, of which

George W. Tillson,	received	36	votes for	President.
A. J. Provost, Jr.,	"	36	"	Secretary.
Calvin W. Rice,	"	36	"	Treasurer.

Mr. Meserole.—We have now reached the time in the Annual Meeting when the President comes to the point of becoming a real "has-been."

It is a very nice point about the Constitution of this Club that the President, when he retires, does so gradually and by degrees, on the installment plan, in fact. He remains in the Board of Directors for another year. You cannot "chase" him any quicker than that. In fact, when we started out, we started with a Past-President who had never been President. We had to elect a Past-President in order to fill that requirement, and Mr. Torrance was the victim. He is the only man who can ever be an ex-President of this Club without having first been President.

It is a peculiar thing about the American people, as Jules Verne says, that whenever three of them get together they immediately form an organization. One of them is elected Chairman and another Secretary, and if there are more than three they have a Board of Officers and a Board of Directors. This Club was formed in something like that informal way; but it has grown to be something that really needs a Board of Directors; it really needs officers, and its members need to know what the officers are doing, as, of course, the management of the Club is, necessarily, in the hands of a few.

It has been my good fortune from the beginning of this Club to be associated with its management. At the time of its organization somebody named me on a committee to help to form the constitution. They then, in their wisdom, or unwisdom, nominated me for Vice-President, and I was elected. Somehow or other the constitution provides that the Vice-President shall stay in office for two years. Then I was elected President. That made me a fixture for two more years, although I was elected for but one. On the whole it looks to me as though I were getting to be a chronic office-holder.

During the time that I have been in office I have seen the Club grow very materially, and it hasn't got through growing yet, I am happy to say. The report of the Secretary shows 160 members, and he did not state the fact that there are now eight applications for membership to be acted on at the next meeting, and in the month to come we will probably have a number more. The Club is growing very materially, and there is no doubt that it is filling a space that existed for just such an organization in this city. At the time it was organized it was claimed there was no room for such a club; that we had the American Society in New York, which was away ahead of anything we could think of putting up, but the result has justified our hopes.

It has been said here to-night that it won't be very long before we have a place of our own. Well, I think that may be so. I think, however, that it will be a good while before we ought to take any step in that direction. We are doing very nicely now, and are running along under a very small expense. The Corporate members of this Club are paying annually but $8 into the treasury.

The analysis of the accounts as read to you to-night will show that nearly all of that money is paid out immediately for the benefit of the Club membership at large. Our income last year was something over $2 000. We spent nearly all of that. We haven't spent all our income, however, but nearly all for Club purposes. The entertainment at the meetings in the way of refreshments has almost entirely been paid for by the members present. Those who were present at the time when we changed the system of payment for suppers know that there was quite a little fund collected by the Entertainment Committee by reason of the fact that they were selling tickets in advance, and which were good for only a limited season, and the returns from those that had been paid for, and not used, formed a fund in the hands of the Entertainment Committee. In that way the Committee was able to give during the past year, I believe, three entertainments, at which the expense of the refreshments was nothing to the members present. But we do not think that that is a good plan. We, therefore, have changed the thing around, so that every member shall pay for what he has had. In that way the Club is going to be at a little expense to carry on the entertainments, by reason of the fact that there will be a few who will have to be entertained at the expense of the Club.

I think it has been one of the strong features of this Club that it has been to a certain extent a social organization. We don't come here just to study as we would go to an evening school. We do get knowledge, we do grow in our profession, but we also grow in acquaintanceship with the members of our profession, against whom we should rub elbows in the outside world; we get to know one another, and it does a fellow a lot of good—I know it does me.

Now, in an organization that I happen to know of, that was spread

pretty well over the United States, in the year 1898, it fell off very materially in membership. There was a great hullabaloo in the organization. They published a magazine, and the man who ran that magazine, and who made a good salary by doing so, and whose earnings depended on the size of the organization, made the statement along in the fall that during the term of their present President he had lost some $30 000. The President retorted: "Well, I haven't got it; you can search me if you want to. Mr. McKinley was also President this year, perhaps he found what you lost."

Now, if there is anything that this Club has lost during the past year you can search me for it, but you won't find it. I am not to blame.

The officers and committeemen are the ones to blame and to praise, for they have been the ones who have brought this Club to the point where it is, with the help of the members. This Club has depended on the good work of every member in it. There is coming a time when there is going to be a great shortage of men to read papers at the regular meetings, and to talk at the Thursday night meetings, which are so very valuable, and that shortage will come all the sooner if a whole lot of the members here don't make up their minds that they can say something, or write something, or do something, to "keep the ball rolling." There are not so many men here but what every man has got to take his part. Don't imagine it is a very pleasant thing for a committee chairman to go around urging people to talk at a Thursday night meeting, or read a paper at the monthly meetings. Of course, somebody has got to be a committee chairman, but make it as easy as you can for him. In the same way I hope the members will do what they can for the new board of officers. I think I can safely put the management of this Club in the hands of the next board of officers, knowing that the new President, whoever he may be (of course, we don't know), and the new committee chairmen he may appoint, and their associates on the committees, will handle the thing so much better than it has been handled this year, that at the next annual meeting you will have a great deal more to be proud of than you have to-day.

The President.—Gentlemen, it is my last official act to declare Mr. George W. Tillson elected as President of the Club for the ensuing year; Mr. Andrew J. Provost, Jr., as Secretary; and Mr. Calvin W. Rice, as Treasurer. It is with great pleasure that I turn over the gavel of this organization to the new President, Mr. Tillson.

Mr. George W. Tillson.—Gentlemen of the Club: My sensibilities would be dull, indeed, were I not gratified at the action which you have taken this evening in making me President of the Brooklyn Engineers' Club for the coming year. I consider it an honor, and I thank you for it heartily and cordially. I wish that I might do as the politicians do, promise each one of you a good office with a large

salary and little work; but as I cannot do that I will guarantee that I will do my best to maintain the high standard which the Brooklyn Engineers' Club has attained among the technical societies of the day. I know what I am saying when I promise this, and I know full well that I cannot accomplish it without the co-operation of the members of the Club.

All of you can do something. Your very presence here encourages the officers, and all those who have to do with the meetings. Some members do their work on committees; others come here and take part in the discussions, and still others present papers which form the nuclei for these discussions, and it has always seemed to me that, in the preparation of a paper (especially if it be one of a scientific nature), we can come nearer to actual creation than in any other way. An idea suggests itself, another follows, the two beget a third, and others come rushing in until at last we have enough to form a complete and logical paper. It is the creation of our own brain, almost something from nothing, and must give satisfaction to any man who has accomplished it.

I know that to prepare a paper for this Club means a great deal of work and patient labor, but I do not believe there is a single member who has prepared such a paper since this Club was organized but has felt fully repaid for his labor in the satisfaction which he has afterwards received.

There is another feature of this Club to which I wish to allude, and that is the social side. I do not believe there is a technical society in the country in which the social features have been developed as they have in this without detriment to the technical part. Generally where a social feature is introduced at all it has been at the expense of the scientific side, but with us it has seemed to be different, and any particular success on the one side has incited the other to greater effort, and the result has been greater developments in every direction. This social feature should be fostered and encouraged in every possible way, for I think to it, in a great measure, is due the present success of the Brooklyn Engineers' Club.

It is customary, gentlemen, for the presiding officer of a technical society, when taking his seat, to detail to some extent the proceedings of the world during the preceding year in which his society is supposed to be most interested. Permit me, however, to vary somewhat from the usual custom, and instead of looking into the past I will ask you to look forward into the future, and consider, for the few moments which I shall ask your attention, what I think will be the next great power or agency in the development of the civilization of the world.

From the beginning of the Christian era down to the present century there have been, if we except the Christian religion, three

great civilizers at work: the alphabet, the art of printing, and the discovery of gunpowder. During the present century the discovery and utilization of the power of steam and electricity has so changed the natural and industrial world that those of us who have seen the greater part of it can hardly realize the transformation which has taken place. And yet civilization required 1 500 years to attain its growth and strength enough to cross the Atlantic. It took 150 years more for it to gain and maintain a foothold on these shores. In 1802 it crossed the Mississippi River. In 1848 it reached California and the Pacific Coast, and now in the latter part of the last decade of the 19th century it has crossed the Pacific and reached the Hawaiian and the Philippine Islands. All these events have been brought about by these agents of civilization of which I have spoken. Without them this would have been a physical impossibility.

And now, standing as we do on the very threshhold of the 20th century, looking forward into the future, can we say that civilization has reached its climax; that henceforth there will be no development. I do not think so, and I further believe that one of the great agencies in its future development will be the collection and storage of heat from the direct rays of the sun.

Heat ! It is the power that moves the world. It drives our express trains, propels our ocean steamships, turns the wheels of our factories, turns winter into summer, and night into day. It supports all vegetable and animal life. Without it this world would be as bleak and bare as is the desert moon. And what more natural that, if we wish to investigate this power, we go to its source, the sun.

The storage of the heat from the rays of the sun. This is going on at the present time, and has been going on for ages. A ray of heat shoots forth from the great orb of the universe which we call the sun. It falls upon a mound of earth in which lies hidden a tiny seed. The heated soil causes the seed to germinate; it bursts forth; becomes a plant, a sapling, a tree, which in its turn bears fruit, falls to the ground and decays. Yes, falls to the ground among thousands of its fellows, which acted on by the elements, and after passing through numberless geologic changes, we find centuries after, perhaps, stored up in the bosom of mother earth, covered by a mantle of virgin soil. We call it coal, but it is the stored up heat and energy of the sun. Stored up, but at how great a loss of efficiency no one can tell. And, now, do you doubt that in this coming twentieth century some man will be found who can so accelerate this action and hasten it, that it can be brought about within a reasonable time, and during the life of man? This will not be a change in the laws of Nature, but it will be accomplished by acquiring such a knowledge of the laws of Nature that they can be so taken advantage of that they seem to produce an anomaly.

Why! go back with me one hundred years, and who so credulous as to believe that man could ever construct a vessel 700 feet long and propel it across the Atlantic in 5¼ days, bearing within its iron sides more than 2 100 men and women, besides thousands of tons of freight. Go back with me 75 years, and who so venturesome as to predict that we could ever travel from the Atlantic to the Pacific in four days, or that we could communicate with our friends across the continent, and even under the ocean from continent to continent as freely as with our neighbors across the street.

Go back with me 50 years; yes, 40, 30 years, and who would have believed that a man could ever sit down at his desk in New York and talk with his agent in Chicago or St. Louis, and even Omaha, and recognize the tones of his voice. But these things are done, and done so commonly that our children take them as much a matter of course as they do the rising and setting sun. Don't you know, gentlemen, that in these times it is the believer who is the conservative man, and the doubter who is the radical ?

Shall I picture to you some of the conditions to be arrived from this discovery ? Think of an ocean steamship starting off on a voyage across the Atlantic without any coal or coal bunkers, and in their places tanks of concentrated heat ! Think of our houses heated without the annoyance and dust of coal and ashes! Think of being served every morning in winter by the heat man, as we are served in summer by the iceman! Think of taking up the morning paper and reading that the good ship *Eldorado* has arrived over night laden with a general cargo, and a certain amount of concentrated heat! Think of Peary starting off on a voyage to the North Pole carrying among his general stores a certain amount of concentrated heat! Think of an air ship propelled by—but I appal your minds, and if I continue to intimate to you the probabilities, let alone the possibilities, of this discovery, you would believe even less of what I am telling than you are believing at the present time.

Do you ask me how all this is to be brought about? I shall be obliged to say I do not know. I wish I did. If I did I would guarantee to build within the next five years a club house for the Brooklyn Engineers' Club such as no society has ever seen. If I did I would be sure that my name would go down honored among those of Morse, Edison, Tesla and Marconi.

How this is to be brought no one can tell. Perhaps by means of electricity. Perhaps by means of liquefied air. Perhaps by some method of which at the present time we have no knowledge, but it is bound to come. It may not in my time. I trust it will in the time of some of you present. And when it does please remember that it was once predicted in the Brooklyn Engineers' Club.

Mr. Andrew J. Provost, Jr.—Mr. President and gentlemen, I don't

know whether it is generally known, but it ought to be, that Mr. Meem writes all the speeches for this Club. Feeling that this call might come this evening, I button-holed Mr. Meem out in the lobby and asked him for my contribution to the speechmaking. He said that he had had some good ones, but had given the best one to Tillson. He said, "I have only one left, but you can have that if you want it." The speech, however, happens to be in Scotch dialect, and I am afraid it is beyond my powers. But I want to thank you all very much for the confidence you have shown in re-electing me as Secretary this evening. I shall endeavor to carry out the duties of the office as well as I can.

I think that the success of this Club is something that we ought to feel proud of, and it may have a good many successes in the future,—such as the club house, which, however, we are not very near to yet. I think that it is quite remarkable that in the three years, or little more, that the Club has been in existence, that this city, or rather borough, has attained through its Engineering Society (if it may be so called), a position among other cities and communities of this country, regarding its number of organized professional engineers, which its population would appear to ultimately justify.

In looking over the membership lists of the various societies in this and other cities, we find, as we naturally would expect, that New York heads the list; that Chicago comes next, in point of local members; Philadelphia next, and Brooklyn (the old City of Brooklyn) comes next, as we would expect. It is closely followed by Boston, St. Louis and Cleveland, in the order named. Therefore, while our membership may increase in the future to some extent, we cannot expect it to increase to a very large degree. And, personally, I believe that with the 160 or more members we have now, if we can only keep up the enthusiasm that has existed during the past years, we shall not need more members, and that with the same kind of work done among us all as in the past, we shall have as good an engineering club and get as good work out of it as anyone could wish.

Mr. Rice.—Mr. President and members of the Brooklyn Engineers' Club, I can only thank you for the great satisfaction and honor I have in this position, which is a great pleasure to me to carry out.

Mr. Meserole, acting for the Committee appointed at the November meeting to confer with Mr. Risse, Engineer-in-Chief of the Topographical Department, regarding the action of that Department in moving and disturbing monuments in the Borough of Brooklyn with regard to line and grade, reported the results of such conference.

He stated that the investigation of the Committee showed that the work was being done carefully, and in a workmanlike way; that records were being kept of the changes made, and that, upon the rec-

ommendations of the Committee, the Engineer-in-Chief had agreed to place records of all changes made in a convenient location in this Borough where local engineers and surveyors shall have free access to them; also, to file there copies of street-opening maps, and changes of line and grade.

The Committee, its work having been performed, asked to be discharged. Upon motion, the report was accepted and the Committee discharged, with thanks.

The meeting then regularly adjourned.

BROOKLYN ENGINEERS' CLUB.*

No. 15.

NOTES ON STREET PAVING MATERIALS AND THEIR USE.

By Nelson P. Lewis, M. B. E. C.

Presented January 12th, 1899.

It is only within the last few years that the municipal engineer has been frequently spoken of, and that municipal engineering has come to be regarded as an important and attractive branch of professional work. Many of our technical schools now have chairs of Municipal Engineering. Up to the close of the last decade a very large percentage of the engineers of the country were engaged in railroad work, and there are probably very few of us who began our professional careers a dozen or more years ago who have not been for some time employed in this kind of work, or are so engaged to-day.

The number of miles of new railroads built in the United States during the decade from 1880 to 1890 was 73 402, of which 11 569 miles are credited to 1882, and 12 878 miles to 1887, while in the five succeeding years the annual increase in mileage was 4 071, 4 419, 2 277, 1 928 and 1 628, respectively. Nearly all the railroads required to transport our products seem to have been completed by the last named year, so that since that time this branch of engineering has offered few attractions.

One of the conspicuous results of cheapened transportation and the facility with which the products of field, forest, mine and factory can

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

be transferred to the consumer, has been the rapid increase in population of all our cities. It is scarcely necessary to repeat the familiar statistics showing the tendency of our population to concentration in large cities.

TOTAL MILES OF STEAM SURFACE RAILROADS IN UNITED STATES, WITH YEARLY INCREASE FROM 1880 TO 1895.

Year.	Total miles.	Increase.
1880	93 296	6 712
1881	103 143	9 874
1882	114 712	11 569
1883	121 445	6 743
1884	125 379	3 924
1885	128 361	2 982
1886	136 379	8 018
1887	149 257	12 878
1888	156 169	6 912
1889	161 353	5 184
1890	166 698	5 345
1891	170 769	4 071
1892	175 188	4 419
1893	177 465	2 277
1894	179 393	1 928
1895	181 021	1 628

In 1890 over 45% of the population of New York State (nearly six millions) was concentrated in four cities, while it is estimated that the greater city of New York contains at present more than 52% of the State's population. Nor is this tendency characteristic only of American cities, though the general impression seems to be that it is more conspicuous with us. In fact many European cities, notably those of Germany, have outstripped ours in growth. To give a few examples;—in 1870 Berlin had about 150 000 less people than New York; in 1890 it had over 73 000 more. In 1875 Hamburg exceeded Boston in population by but 6 000, while in 1890 the German city was more than 121 000 ahead. Breslau has grown from 272 900 in 1880 to 335 200 in 1890 (or 23%), while our thriving city of Cincinnati has in the same period increased from 255 100 to 296 900, or 16 per cent. Taking a number of

German and American cities of about the same size, it is seen that during the decade from 1880 to 1890 the increase in population was:

Cities	Population 1880.	Population 1890.	Per cent. increase.
Breslau	272 900	335 200	22.8
Cincinnati	255 139	296 309	16.1
Cologne	144 800	281 800	94.6
Buffalo	155 000	255 664	65.0
Dresden	220 800	276 500	25.2
New Orleans	216 000	242 039	12.0
Hanover	122 800	163 600	33.2
Louisville	123 758	161 005	31.0
Nuremberg	99 519	142 523	43.2
Providence	104 857	132 099	26.0
Chemnitz	95 000	138 955	46.3
Rochester	89 366	133 896	49.8

But this remarkable growth is not limited to Germany. It is found to be true of most of the capitals and principal cities of Europe, as the following percentages of growth in the decade ending in 1890 will show:

City.	Per cent.
Amsterdam	24
The Hague	33
Paris	8
Lyons	$19\frac{3}{4}$
Florence	42
Budapesth	43
London (County)	10
London (Metropolitan Police District)	18
Glasgow	16
Edinborough	11

Meanwhile the rural population the world over has increased very slowly, or has positively decreased. The massing together of large numbers of people without proper regard to sanitary conditions has always resulted in great mortality, as witness the terrible plagues which have swept over the old cities of Europe, and the disastrous results during the past summer of concentrating large numbers of our volunteers in camps not subjected to rigid sanitary regulations.

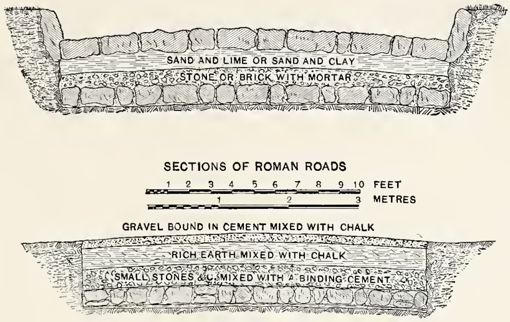
It has been amply demonstrated, however, that our cities can be made at least as healthful as the country districts, and an increasingly large number of engineers are engaged in this city building. It is to one branch of this municipal work that I wish to ask your attention this evening,—that of street improvement. The first impression gained by a stranger entering a city is undoubtedly that produced by the appearance of its streets. If they are poorly paved, irregular, dirty and generally unkempt, he will consult his time table to see how soon he can get away. If they are broad, smooth, clean, well shaded and lighted, he will stay as long as possible.

In spite of the pride of the American people in the development of our cities, and notwithstanding the fact that their wealth enables them to have only the best, they have been slow to appreciate the value of thoroughly well-paved streets. European cities have been ahead of us in accepting the doctrine as stated by Mr. Albert Shaw, "that smooth and clean highways are a wise investment from every point of view, and that so long as the work is done in a thorough and scientific manner, the result is worth having, regardless of cost. No city should think itself rich enough to prosper without them, and no city is so poor that it cannot afford them if it has any reason whatever for continued existence. Good roadways are cheap at any cost, and bad ones are so disastrously expensive, that only a very rich country like the United States, can afford them."

The very fact that the street pavement is a matter of such everyday concern, and the difference between good and bad pavements is so apparent to the most casual observer, will probably account for the fact that its construction and maintenance has not been thought to require the same expert engineering supervision as is concededly necessary in designing and building systems of water supply, or sewerage, but that almost anybody can build a street as long as he has the earth for a foundation, though when the street is to be carried across a waterway, it is conceded that a trained engineer is required.

Engineering involves the economical use of the materials and resources which are available to the accomplishment of the object in view. It is as reprehensible to waste material and money in the construction of a street or its pavement as in the building of a bridge. In the former case the waste will not be apparent, but that is the greater reason why it should be avoided by the conscientious engineer.

I shall not attempt to give you a history of street paving, or



Sections of Roman Roads.

Street in Pompeii.

attempt to sketch its development, but will briefly refer to the different kinds in general use, and the kind most in favor in various cities. I suppose no one has ever introduced the subject of pavements without reference to the Roman roads, and I will not be so radical as to violate all precedent.

While Carthage was probably the first city to boast of paved streets, the Romans followed its example, and all over Europe, Asia and Africa, as far as the domain of their Emperors extended, they built with the greatest care and at enormous expense that magnificent system of roads which were often supposed in the middle ages to be of supernatural origin and which remain the wonder of our modern civilization. The principal arteries were military roads built to facilitate the marching of armies and were built and maintained by the imperial government, while others were for commercial purposes and the expense of their construction and repair was borne by the municipal governments. These roads were generally from 4 to 6 met. in width and were constructed in this way:—The roadbed was excavated and in it was placed a layer of stones which were sometimes united with mortar. These stones were such as were most available, sometimes rounded stones similar to the cobble stones with which we are familiar, and in some cases in the Alps the foundation was a compact mass of angular stones, 2 ft. or more in their longest dimension, carefully fitted together.

On this foundation was placed a layer of plaster made of stone or brick pounded with mortar, then a course of sand and lime or sand and clay, leveled and pounded until very hard. The top or wearing surface was made of irregular flat stones, fitted together with nicety and united with cement. The total depth of these roads, or pavements, as they can properly be called, was from 3 to, in some cases, 7 ft. It is said that in the province of Hispania alone (Spain and Portugal) 20 000 miles of roads were built. We think of Rome as conquering the greater part of the civilized world by her magnificent legions, and forcing her civilization upon it by her army, but who shall say how much of her success was due to the splendid system of roadways that enabled her to quickly concentrate her forces and hurl them against the enemy in emergency, and which during the brief periods between her wars stimulated the arts of peace and facilitated commerce between her provinces and cities?

What was undoubtedly the first stone pavement laid in the new world was in New York City—or New Amsterdam—in 1657. The first Van Cortlandt established a brewery, according to a book recently written by Mrs. John King Van Rensselaer, which was located on what was previously called "the road," lying between Broad and Whitehall Streets, and afterwards called Brower Street. The Dutch housewives were much annoyed at the dust raised by the brewery wagons, which marred the neatness of their kitchens, and, through the influence, it is said, of Madame Van Cortlandt, the authorities were prevailed to pave the roadway with small, round stones. This improvement excited the liveliest interest and the country people visited it as a curiosity. It soon came to be called "the stone street;" its original name was forgotten and it survives as Stone Street in Manhattan Borough to-day.

The first stone pavements to be laid in modern city streets were those formed of stones in their natural condition, variously known as boulders, pebbles or cobblestones. This kind of pavement, as well as the name of the street, has been persistent, and, on account of their availability and cheapness, these cobblestones continued to be used in many cities until within a very few years. When they were well shaped and uniform in size they made quite a durable pavement, and though rough and noisy were capable when carefully laid of sustaining a considerable traffic. The best of these stones used in our eastern cities were known as water stones, and were beach pebbles, egg-shaped, varying in size from 3 to 8 ins. in their smaller diameter, and large quantities were formerly taken from Block Island. They were laid as closely as possible with their small ends down on a foundation of sand, the smaller stones in the central part of the street, and the larger ones at the sides. Fortunately the better class of these stones are now so scarce, and the poorer ones are so execrable, that this type of pavement is becoming obsolete, though there are many miles for which more civilized pavements are yet to be substituted. The next step in advance was the use of stone shaped to uniform size, or approximately so, and with a more or less smooth surface. This is the pavement in most general use to-day, and for permanency, and consequently cheapness, cannot be surpassed. When first used these blocks were quite large, and the size has been decreased until the best stone pavement laid at the present time in

Street in Naples.

Great Britain are 6-in. cubes, or still smaller, with a surface 4 ins. square and a depth of 7 ins. It is interesting to note the kind of block in general use to-day in various cities, as shown by the following table:

SIZES OF PAVING BLOCKS USED IN DIFFERENT CITIES.

Cities.	Material.	Length. Inches.	Width. Inches.	Depth. Inches.
Paris	S. Gr. Por.	$6\frac{1}{2}$ to 8	$5\frac{1}{2}$ to $7\frac{1}{4}$	$6\frac{1}{2}$ to 8
Berlin	Gr. Por.	$7\frac{1}{2}$ to 8	Cubes.	....
Magdeburg	Por.	$7\frac{1}{2}$	$5\frac{1}{2}$	7
Vienna	Gr.	$7\frac{1}{2}$	Cubes.	....
Trieste	S.	24 to 60	12 to 18	6 to 10
Brussels	Por. S.	$6\frac{1}{4}$	$5\frac{1}{2}$	6
Genoa	....	$27\frac{1}{2}$	$11\frac{2}{3}$	$7\frac{2}{3}$
Genoa on steep grades	....	29	$5\frac{3}{4}$	$7\frac{2}{3}$
Barcelona	....	$7\frac{1}{4}$ to 8	$3\frac{1}{2}$ to 4	$6\frac{1}{2}$ to $7\frac{1}{4}$
Valencia	....	$13\frac{1}{2}$	$6\frac{3}{4}$	6
London	Gr.	4	4	7
Leeds	Gr.	6	Cubes.	....
Liverpool	Gr.	8 to 12	3	6

S. sandstone, Gr. granite, Por. porphyry.

You will see that those cities, notable for their highest municipal development, have small sized, carefully cut blocks in the laying of which no expense is spared, and when 6-in. cubes or a 4-in. block 7 ins. deep is specified it means just that and nothing else will be accepted. No data could be obtained as to pavements in St. Petersburg, but it is said that Dumas, upon his return from that city, when asked how he had found the streets, replied, that he had scarcely seen any, as during the winter they were covered with snow, and during the summer they were in process of repair.

But stone pavements when most carefully laid and maintained are noisy and unpleasant to ride over, and in these days we can never reconcile such a pavement with a handsome residence street. I experienced a distinct shock when on riding over Euclid Avenue, in Cleveland, last summer I found it still paved with Medina sandstone blocks, and it seemed to me that this famous street was still living on the reputation which Bayard Taylor gave it years ago as the handsomest street in the world.

In looking about for something more quiet and smooth than stone the first material tried was wood. In London the first wood pavement was laid in the Old Bailey in 1839 and was soon followed by many others. None of these pavements lasted more than seven years,

and as they cost more than granite, and were so short lived, a prejudice arose against them, and as they wore out they were mostly replaced with granite, and at the close of the year 1873 there were only between 12 000 and 13 000 sq. yds. of the pavement in the city. Since that time wood pavements have become popular again and a large area is now covered with them. The material most generally in use is the Baltic fir, though there is quite a large amount of Australian hard wood which is more durable. The people of London seem willing to bear the greater expense and submit to the annoyance of more frequent renewals for the sake of the quiet, and wood is certainly the least noisy of all known pavements.

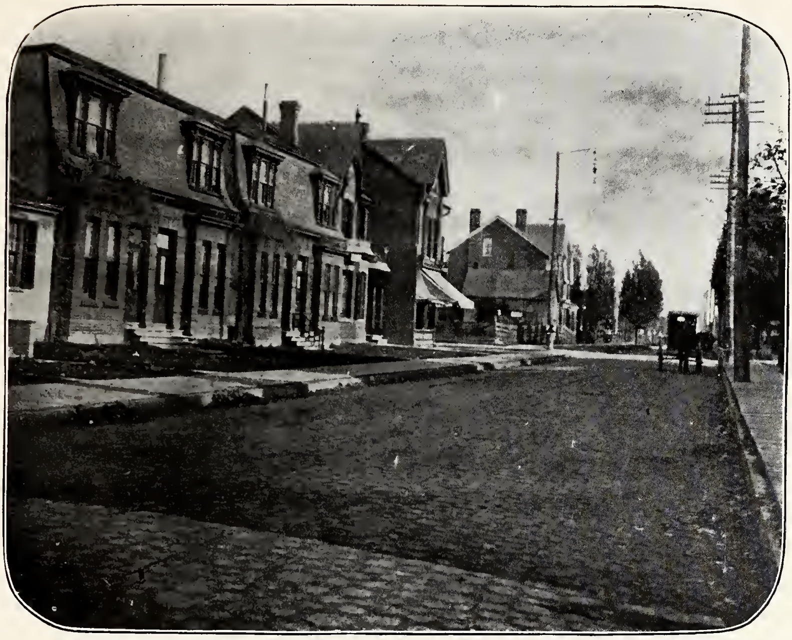
Paris had in 1891 more wood than asphalt, the areas of pavements of different kinds being as follows:

Kind.	Square meters.	Per cent.
Stone	6 336 900	73.4
Wood	484 900	5.6
Asphalt	301 400	3.5
Gravel	1 510 200	17.5

There is a general impression that Paris is a city of beautiful asphalt pavements, which is not the case.

Berlin also has some wood pavements, but asphalt seems more popular, though by far the greatest area is still of stone pavements.

It is unfortunate that the first wood pavements laid in this country were of the Nicholson block, which proved to be short lived and very unsatisfactory. The first of these blocks to be laid were of yellow pine, but spruce was soon substituted, and a very inferior quality at that. They were without special treatment of any kind, were laid on a course of plank, and tar was then poured over them in liberal quantities. The tar doubtless formed a cover for sappy and otherwise defective wood; it simply closed the cells on the exterior of the blocks preventing the moisture from escaping, and I have seen many of them which, when removed, could be picked to pieces with the fingers. This pavement lasted but a few years and was generally condemned. In Brooklyn considerable of it was covered with asphalt, and has resulted in the most expensive of these pavements which this city has had to maintain. The most durable wood pavements are those made of the hard woods of Australia, which are especially adapted to this purpose.



Cedar Block Pavement, First Stage.

Cedar Block Pavement, Second Stage.

They are mostly of the Eucalyptus family,—the red gum, blue gum, black butt, tallow-wood and mahogany. Mr. George W. Bell in a pamphlet published in 1895 gives some remarkable statistics as to the durability of these pavements. He cites the case of George Street in Sidney, which sustains a very heavy traffic, and on which a wooden block pavement had been in constant use for over ten years without repair of any kind, when it was relaid from open to closed joints, the former method of laying having proved to be a rough pavement. It is claimed that blocks taken from the middle of the roadway had worn on an average only $\frac{1}{28}$ in. per year, or less than $\frac{1}{2}$ in. in about 11 years. Mr. Bell states that the report of the City Surveyor of Sidney claims that one wood pavement on the busy streets outlasts three made of stone cubes. It is scarcely probable that such satisfactory results would be obtained in our climate. The only piece of wood pavement of this class which has been laid in this country to my knowledge is on Twentieth Street, between Broadway and Fifth Avenue, in the Borough of Manhattan, New York City, where in 1896 the Australian "Kari" wood was laid. The work was done with the greatest care, and the resulting pavement is certainly a handsome one. When Fifth Avenue was repaved in 1897, it was suggested that this material should be used, but, on account of the popular prejudice against all wood pavements and the delay which would be involved in obtaining the blocks, the idea was abandoned.

When wood pavements are spoken of in most of our cities the tax-payer pictures to himself the round cedar block so generally in use in western cities. These are used on account of their cheapness. They are usually laid on one or two courses of plank. The blocks are round from 4 to 8 ins. in diameter, and 6 ins. in depth, are set as closely as possible to each other, and the joints are filled with gravel, after which they are usually poured full of pitch. Such a pavement, when new, is quite agreeable to ride over. It soon, however, becomes uneven, the defective blocks quickly decay, the surface not being impervious to water, the wet foundation under a pavement with so little rigidity becomes soft, and the mud or slime works its way up between the blocks, and the process of decomposition is expedited. We hear sometimes of the floating pavements of Chicago. These are such cedar block pavements which are said to rise with the floods of water filling the roadways after heavy rainfalls, and from specimens of the pave-

ment I have seen in that city, considerable sections must have floated away. Similar cedar blocks are laid in Detroit on carefully prepared foundations, and have given satisfactory results there for from eight to ten years. The round block has nothing to recommend it but its cheapness, and this usually proves to be expensive economy. There seems to be a revival of interest in the rectangular block pavement at present. In Galveston, Texas, creosoted yellow pine blocks have been laid for some years with general satisfaction. They are laid directly on the fine sand which is water rammed so as to be very compact. The surface is formed with great care by a template to the exact grade and crown, and the joints are filled with similar fine sand. In Indianapolis similar creosoted blocks have been laid for several years, 60 000 sq. yds. having been put down during the past season. It has been laid as closely as possible on a concrete foundation, with a sand cushion of 1 in., and the joints filled with paving cement, composed of 10% of refined Trinidad asphalt, and 90% of coal tar distillate, after which the surface is covered with ½ in. of clean coarse sand, or granite screenings.

Improved wood pavements are a luxury. They have many points of superiority over asphalt. They are so considered in London where their use is continued, although they require renewal oftener than asphalt and much more often than granite. They will undoubtedly be used more frequently in this country when the people are willing to pay the additional cost for the quiet and for the freedom from the dust and disagreeable glare of asphalt.

The pavement which is to-day, more generally than any other, superseding stone on all streets where the traffic is not excessive nor the grades extreme is asphalt. It is scarcely necessary to attempt to give a history of the use of this material, how its adaptability to paving purposes was first discovered by the improved condition of the roads over which it was hauled from the French mines for use in reservoir and tank linings, etc. The drippings from the carts were observed to have been compacted by travel until a smooth, hard roadway resulted. The first street to be paved with it was Rue Bergéra in Paris in 1854, and it was so successful that in 1858 Rue St. Honoré was similarly treated. An asphalt pavement was laid in Threadneedle Street, London, in May, 1869, and in Cheapside and Poultry in the fall of 1870, while in Berlin its use began in 1873. Paris now has

Cedar Block Pavement, Third Stage.

Cheapside, London.

approximately 410 000 sq. yds., London 215 000, and Berlin 1 750 000 sq. yds.

The laying of bituminous pavements in this country began in 1869, and tar concrete or Scrimshaw was first used. Asphalt began to be used within the next year or two, and its popularity has been astonishing, as will be seen from the fact that on January 1st, 1898, the area of this kind of pavement laid in the United States was, as nearly as could be ascertained, 30 000 000 sq. yds.

Buffalo has at present nearly 4 000 000 sq. yds. (or more than all the European capitals combined) and Washington had on June 30th, 1897, 2 761 755 sq. yds., of which about 433 000 yds. is coal tar and concrete, and 318 000 are asphalt blocks.

There is a notable difference between the European and American asphalts. The former may be called natural and the latter artificial pavements. In the former the material as it comes from the mine is ground to a powder, heated, placed upon the foundation prepared for it, and tamped into approximately the same condition as before it was disturbed, though usually the product of several mines are mixed in order to obtain the best percentage of bitumen, but nothing is added to or taken from the bituminous rock. In the pavement usually laid in America, on the other hand, only a small proportion of the material is brought from the asphalt deposits, the principal part of it, sand, being obtained near at hand. In the one case the cost of long ocean or rail transportation has to be paid on the entire mass forming the pavement, while in the other, this expense attaches to but 12 to 15% of the material. This is, of course, a great advantage, and at recent prices it is scarely possible for the European rock asphalts to compete with the artificial ones.

Information as to the production of asphalt and the way in which it is combined with other materials to form street pavements is now so easily accessible that it is scarcely necessary for me to take up your time by dwelling upon either. Recent specifications for such pavements are quite explicit in describing the making of the pavement, but it must be admitted that municipal engineers have obtained most of their knowledge of the subject from the asphalt companies. Three or four years ago there were scarcely half a dozen chemists in the country who claimed to know much about asphalt. Knowledge of the subject was largely empirical, and most chemists will admit to-day that they

cannot detect with any degree of certainty the adulteration of asphalt with tar unless there is enough to tell it by the odor. It is difficult even to describe it. Is it any wonder, then, that most of our knowledge has been gained from the successes and failures of the asphalt paving companies ?

As far as I know there are but two municipal asphalt laboratories in the country and they are in Washington and Brooklyn. The making of an asphalt pavement is a physical not a chemical operation, and the chemical tests applied consist simply in analyses of the materials used, before they are combined, and the separation of the paving mixture to determine whether or not various ingredients, already found to be satisfactory, have been combined in their proper proportions. At the risk of telling you what you already know, I will briefly describe the making of a pavement from one of the standard asphalts. The material as found in nature has this composition:

Bitumen	38.14	per cent.
Organic matter, not bitumen	7.63	"
Mineral matter	26.38	"
Water	27.85	"
	100	"

or,

Bitumen	52.86	per cent.
Organic matter, not bitumen	10.58	"
Mineral matter	36.56	"
	100	"

This is refined (and the refining is little more than cooking until the water has been driven off, and some of the mineral matter has settled), until it is composed of:

Bitumen	57.47	per cent.
Organic matter, not bitumen	7.05	"
Mineral matter	35.48	"
	100	"

These are analyses of Trinidad Pitch Lake asphalt (crude and refined) by Clifford Richardson, and are particularly favorable results so far as the percentage of bitumen is concerned.

ANALYSES OF REFINED ASPHALTS, ROCK ASPHALT, ASPHALTIC CEMENT AND CALIFORNIA MALTHA.

LABORATORY OF DEPARTMENT OF HIGHWAYS, BROOKLYN.

Kind of asphalt.	Total bitumen.	Organic matter non-B.	Mineral matter.	Petrolene.	Sp. gr.
Trinidad Lake.......	53.79	8.74	35.47	70.59	1.39
Trinidad Land.......	53.72	9.39	36.89	69.10	1.41
Bermudez............	94.57	2.79	2.64	77.08	1.08
Alcatraz.............	84.25	1.73	14.02	71.34	1.18
French rock.........	9.76	0.78	89.26	86.27	....
Asphalt cement......	61.10	7.74	31.16	....	....
California maltha...	99.80	....	0.22	....	....

It should now have the following qualities. It should soften at from 189° to 192°, and flow at from 200° to 210° Fahr. It should volatilize from $2\frac{1}{2}$ to 3% of oil in 10 hours at a temperature of 400° Fahr., and should have a specific gravity of about 1.38.

Now, to each 100 lbs. of this material there is usually added about 18 lbs. of heavy petroleum oil as a flux (though a liquid asphalt or maltha—almost pure bitumen—is now frequently used for this purpose). This is petroleum from which the lighter oils have been removed by distillation until it has a specific gravity of 18° (0.945) to 22° (0.92) Beaumé. It should have a flash test of not less than 300° Fahr.; a fire test not less than 350° Fahr.; should have no appreciable amount of matter volatile under 250° Fahr., and less than 10% at 400° in 10 hours. Now we have the asphaltic cement ready to combine with mineral matter. This mineral matter is so selected that when asphaltic cement is added at the rate of about 17 lbs. of the cement to about 83 lbs. of the other, all the particles will be coated and more could not be added without making the pavement too soft. What is found to accomplish this best is fine stone dust and sand. The stone dust is finely powdered limestone, granite or quartz, all of which will pass a 30-mesh screen, and 75% will pass a 100-mesh screen. The sand should be hard grain, moderately sharp and clean. All of it should pass a 10-mesh screen; 20%, an 80-mesh, and at least 7%, or, still better, 10%, a 100-mesh screen. The asphaltic cement and sand are heated separately to about 300 degrees. The stone dust is then added to and mixed with the hot sand in proportion of 5 to 80 in the case of fine, well-graduated sand, and 15 to 67 for coarse sands, having less variation in size. The asphaltic cement is then added, and the

materials are mixed to a homogeneous mass, which is ready to be taken to the street. It should reach there at a temperature not less than 250°, is spread with hot iron rakes so as to give usually a thickness of 2 ins. after consolidation. After spreading, it is rolled with a hand roller, after which a small amount of hydraulic cement is swept over the surface, and it is thoroughly rolled with a steam roller of not less than 10 tons, the rolling to be continued as long as the roller makes any impression on the surface.

I have not described the foundation, nor have I stated that between it and the wearing surface there is generally laid what is called a binder course, 1 in. thick, and formed of small broken stone, to which has been added asphaltic cement, the same as is used in making the wearing surface. Six or seven pints of this cement is used to each cubic foot of stone. Coal tar distillate was formerly quite generally used for the binder, and is still so used in many places. The asphalt has been used exclusively in Brooklyn for the past four years.

Now you will ask: "With so many bituminous substances occurring in nature, many of which we know to be unfit for paving, how can you tell that the contractor is using one which will make a good pavement?" A few years ago this question would have been answered: "The only safe plan is to let the contract to a reliable company, using material which it has been clearly demonstrated will made a good pavement, exact a guarantee for maintenance, protected by sufficient security, and don't worry about the result." This is rarely satisfactory to the engineer, and yet there is, or rather was, much to be said in its favor. There is one city which has followed this advice to its logical conclusion, the City of Akron, O.

But the municipal engineer of to-day is scarcely satisfied with this plan. He knows that there are many sources of supply from which asphalt suitable for paving can be obtained, and he feels that, in justice to the city he serves, he should describe what he wants, and get the benefit of competition.

We must be more specific, therefore, than we were when we said that the refined asphalt must contain 55% of bitumen, should soften and flow at certain temperatures, etc. We must insist that it show toughness and ductility. It has been recognized for sixty years or more that the bitumen, forming the greater part of the refined asphalt, should be subdivided into two substances, which are commonly called

petrolene and asphaltene. It has been found that a bitumen suitable for asphalt pavement should contain at least 70% of the former or petrolene, which is supposed to give the asphalt its cementitious qualities. It is soluble in petroleum naphtha, while the asphaltene is not. Our specifications should provide, therefore, that about 70% of the bitumen (or the portion of the asphalt found to be soluble in bi-sulphide of carbon) should be soluble in petroleum naphtha at 72° (0.68) Beaumé. It has recently been claimed that this determination of the percentage of petrolene is incorrect, as the asphaltene itself is soluble in a solution of petroleum naphtha and petrolene, so that chemists have shown several times too much petrolene. It must be admitted, however, that the relative amount of this cementitious element can be thus determined, so that this test will answer our purpose.

Now, as to the sand which forms so large a proportion of the pavement. The importance of a careful selection of this material has only lately been fully appreciated. An essential part of the examination of a specimen of asphalt pavement is the separation of the mineral matter (after extraction of the materials soluble in bisulphide of carbon) determining the percentages retained on sieves of different sizes.

Sizes of Sand Used for Asphalt Paving in Washington in 1894 and 1897—(Dow).

	Meshes per square inch.	1894.	1897.
Retained on................	20	4.5%	2.5%
" "	40	40.0%	21.0%
" "	60	32.0%	35.0%
" "	80	9.5%	8.5%
" "	100	6.0%	10.0%
Passing....................	100	8.0%	24.0%

Mr. A. W. Dow, Inspector of Asphalts and Cements, in the District of Columbia, in a paper read before the American Society of Municipal Improvements in October, brought out the importance of this detail very forcibly. He cites a controversy had with a representative of an asphalt company, who insisted that the sand which was called for, and which was being delivered, would not prove satisfactory, it being at the time wet and cheesy, so that it could be cut out in big cakes. It was an unpromising mortar sand, but Mr. Dow called attention to the

fact that this sand, which was finer than that previously used, was more strongly held together by water, and explained that it would be held together proportionately stronger when the asphaltic cement occupied the voids.

SIZES OF MINERAL MATTER FOUND IN SOME BROOKLYN ASPHALT PAVEMENTS.

	Percentage Retained on Sieves of Different Meshes per Lineal Inch.						
	10	20	40	60	80	100	Finer than 100
1	0.05	8.95	26.68	29.16	9.95	2.02	23.19
2	0.14	1.05	14.21	50.12	6.87	1.18	26.43
3	....	0.37	14.44	54.41	10.90	1.58	18.30
4	7.31	16.39	27.70	24.04	11.85	2.44	10.27
5	0.76	0.80	0.98	2.78	54.63	15.65	24.40

5 was a rock asphalt pavement.

Very fine sand has a small percentage of voids, so has sand so graduated in size that the smaller grains occupy the spaces between the larger ones. The latter, having a smaller aggregate area to be coated, is preferable as it requires less asphaltic cement. When the masses of the cement are larger there is more of a tendency for the grains to float about in it, and the resulting pavement, though made with a harder cement, will be much softer, marking more readily under traffic and cracking at least as easily in cold weather.

I believe that under a specification framed on the lines described we can be sure of getting material which will make a good pavement. It is certainly true that engineers should be able to prescribe the method of making and laying an asphalt pavement, and promptly detect and correct any irregularity in the materials and mixtures, instead of copying specifications prepared by the asphalt companies. It is claimed by some engineers (not those, however, who are laying pavements), that it is unprofessional to exact any guarantee, but that the municipal engineer should himself assume all responsibility, and stand or fall by the success or failure of the pavement laid under his direction. When we are using a material so variable as asphalt, one requiring such nicety in mixing and such skill in handling, this view seems to me quixotic.

When the general use of asphalt began in Brooklyn, and before the

establishment of our own laboratory it required several days to obtain from the best equipped general laboratory a report showing the percentage of bitumen in a sample of pavement. This report can now be obtained from our own chemist in four or five hours.

The subject of maintenance of asphalt pavements once laid is an important branch of this subject, but in the limited time allowable it cannot be touched upon. The cost of maintenance in this country is far below that in the principal European cities. It is true they are as a rule more perfectly maintained there, but the difference in expense is by no means commensurate with this superiority. The cost of maintenance in London has been from 15 to 35 cents per square yard per annum, while in Washington the cost for the year ending June 30th, 1897, was but three cents per square yard of area maintained. This may be due in a great measure to the generous width of the streets of the National Capital and the fact that the traffic is much lighter than in European cities, but it is certainly also due to the excellent character of the pavements laid there and the economical methods adopted for their maintenance.

In other American cities—and this was formerly the case in Europe—long term contracts were made with the original contractor for maintaining the pavements, or supplementary contracts were made for a term of years.

The contractor is in either case obliged to estimate or rather guess the amount of repairs which may be necessary. The character of the traffic may change entirely, and what was a quiet residence street when paved, may, before the expiration of the maintenance contract, become a busy thoroughfare. These possibilities must be taken into account by the prudent bidder, and he is going to estimate on the safe side. In the District of Columbia, on the other hand, contracts for maintenance after the expiration of the five years' guarantee are made upon the basis of the amount of material used, which is paid for by the cubic foot, and the contractor is sure of being paid for all of the work he is called upon to do. This, of course, precludes the exaction of any guarantee of the material put down under repairs, but with our present knowledge of the subject it should be possible to detect any irregularity or carelessness and promptly correct it.

For a dozen or more years brick has been used for street pavements in West Virginia, Ohio and Illinois. Owing to the fact that its cost

when near the place of production was considerably less than asphalt, and as it is much smoother than stone block it became very popular in western cities, in many places being laid on a sand foundation for less than $1 per square yard. The West Virginia brick is made principally of fire clay, while that of Ohio and Illinois is largely of shale. The most satisfactory are those in which a mixture of shale and clay is used in about equal parts. Such are the brick now made at Catskill, which have given good satisfaction in this city for the past two years.

Time will not permit of a description of the methods of manufacturing brick, nor of the manner in which they are tested. The laying of the pavement is a very simple operation, a concrete foundation similar to that for asphalt being used in the best construction. The joints are sometimes filled with sand, usually with either Portland cement grout or paving pitch. The cement grouting, if it can be perfectly done, gives a very smooth and durable pavement, if the brick are hard and of uniform quality; but it is more noisy, and there is sometimes a very disagreeable roaring noise noticeable in connection with such pavements. The brick on one block so laid in Brooklyn was renewed within a year and asphalt was substituted, owing to the persistent complaints of the property owners who declared that they could not tolerate the noise.

In my judgment the pitch joints are worth the somewhat greater cost. This is certainly the only filler which should be used along and between street railroad tracks. One of the most satisfactory specimens of brick pavement in any eastern city is that on Ninth Avenue, between Thirteenth and Fourteenth Streets, in the Borough of Manhattan. This pavement, a view of which is given, has been in use for about seven years; has been subjected to heavy traffic, and has had no repairs. The average paving brick contains about 65% of silica, 20 to 25% of alumina, 4 to 8% of sesqui-oxide of iron, and small amounts of lime and magnesia, the smaller the better.

One other pavement which must be considered is macadam. Though largely used in some cities as a street pavement, and offering a most agreeable surface for driving when well maintained, its use should, in my judgment, be restricted to park drives and boulevards and the suburbs. It is the most expensive of all street surfaces to keep in thoroughly good condition, and upon ordinary streets it is

Brick Pavement, Ninth Avenue, North of Thirteenth Street, Manhattan, New York City.

Kings Highway, Brooklyn, New York City.

rarely, if ever, so maintained. The macadam or gravel streets of Paris cost annually for general repairs (according to a report made to the State Department by Consul-General King in 1891) from 1.3 to 3.7 francs, or from 26 to 74 cents per square meter, which is more than is expended upon any other pavements in that city. Yet while the system of maintenance in France is elaborate, the force is thoroughly organized, and the small economies of which the French are so capable are exercised in this as in all their public works. Who would venture to estimate the cost of similarly thorough maintenance in this country under the system generally prevailing?

Constant sprinkling is essential, if such roads are to be well kept up, and this is a considerable expense to the city, and the property owners are never willing to do it themselves. I am frequently asked to advise property owners, who are anxious to have streets in suburban districts improved, as to whether macadam would be preferable to asphalt. While feeling that it is desirable to preserve their suburban characteristics, and that a well built and well kept macadam pavement would not only do this, but afford the most agreeable streets for private residence, I feel obliged to recommend asphalt, the first cost of which will be greater to the property owners, but the subsequent expense of which to the city will be much less.

Macadam in the city, therefore, should only be considered as a temporary road, but is often the only kind of improvement which can be properly recommended. Such a road or street will open up new districts, and greatly stimulate building and other improvements. When built with this in view, it should be economically done with the best materials available, paying somewhat more for a stone which has better wearing qualities, rather than using inferior materials, though close at hand. Do not make your roads unnecessarily wide; 16 to 20 ft. will be enough. Use stone enough to carry the loads which will be hauled over them without breaking through, but remember that the real value of your road depends upon its length, rather than upon its depth or width. The subject of road building could properly occupy an evening itself. If you wish to look into it you will find quite a thorough discussion of the subject in the *Proceedings* of the American Society of Civil Engineers for October, 1898.

Having superficially reviewed the different kinds of paving materials, let us consider briefly their use.

The first question to arise, where it has been determined to pave a street, will be the selection of material, or the kind of pavement to be laid. In determining this the governing considerations will be: the traffic to be sustained, its density and character, the rate of grade, and the presence or absence of railroad tracks.

If the traffic be very heavy, and the street given up wholly to business, ease of traction, durability and economy of maintenance are of first importance, while quiet, comfortable riding and beauty can be sacrificed to them. Many efforts have been made to determine the relative force required to draw a load over different kinds of surface under similar conditions. The following is from a table compiled by Mr. Rudolph Hering, from different authorities, the force being that necessary to move 1 ton on a level grade at a speed of 3 miles an hour:

Kind of road.	Pounds.
Ordinary dirt road	224
Ordinary cobblestone	140
Good cobblestone	75
Common macadam	64
Very hard, smooth macadam	46
Good stone block	45
Best stone block (London)	36
Asphalt	17
Granite tramway	12½ to 13½
Iron railway	8 to 11½

The traction tests made by the office of Road Enquiry of the Department of Agriculture show somewhat different results:

Kind of road.	Pounds.
Loose sand—experimental	320
Best clay	98
Cobblestone	54
Best gravel—park road	51
Poor block pavement	42
Best macadam	38
Poor asphalt	26

While the first table gives the results obtained by seven different experimenters the latter is the result of observations made by one person, so that they should be relatively more accurate.

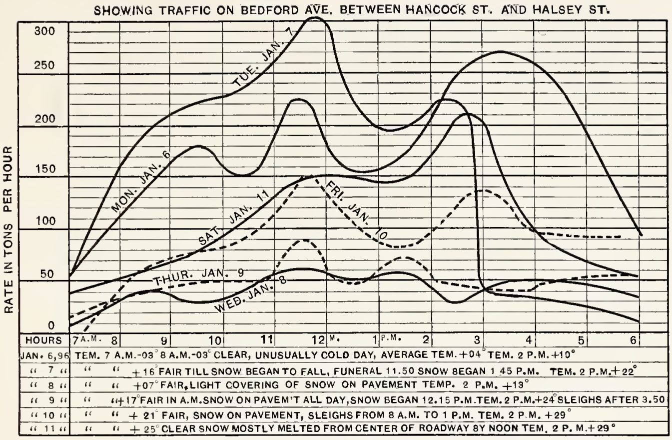
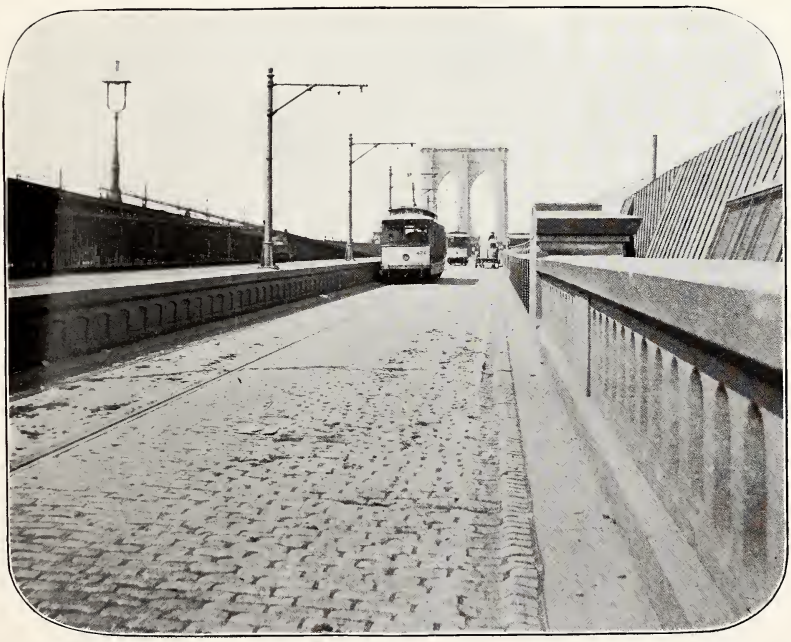


Diagram of Traffic, Bedford Avenue, Brooklyn, January 6–11, 1896.



Pavement on Brooklyn Bridge.

The tractive force as given in these tables is for a level road. When grades are considered, the results are quite different, although, unfortunately, there are no statistics available by which the materials already considered can be compared. The effort required for a horse to haul 1 ton up a grade on different kinds of pavement does not vary as it does on a level, as the foothold afforded by the paved surface varies greatly. The following table given by Byrne in his book on Highway Construction gives the proportion of the load hauled on a level which can be moved by a horse up different grades on four kinds of surface.

Grade.	Earth.	Stone blocks.	Broken stone.	Asphalt.
Level	1.00	1.00	1.00	1.00
1 : 100	.80	.72	.66	.41
2 : 100	.66	.55	.50	.25
3 : 100	.55	.44	.40	.18
4 : 100	.47	.36	.33	.13
5 : 100	.41	.30	.29	.10
10 : 100	.26	.14	.16	.04
15 : 100	.10	.07	.05	....
20 : 100	.04	.03	....	....

The origin of these figures is not stated, and they are not given as authoritative. According to them, a horse loses as much power by reason of a 1% grade on asphalt, as on a 5% grade on earth, and can haul the same proportion of his level load up a 15% grade on an earth road as on a 5% grade on asphalt. This would doubtless be true if the asphalt pavement were both dirty and slightly wet, while when covered with a thin coating of snow, horses can scarcely stand, but it does not seem probable under ordinary conditions. It is difficult to fix a limit to the grade upon which an asphalt pavement should be laid, as this will depend entirely upon the amount and kind of traffic it will be called upon to sustain. It would probably be advisable to limit the use of European rock asphalts to grades of 2½%, though on one street in Brooklyn this material has been placed upon a grade of 4¼% and there have been no complaints of slipperiness. Artificial sheet asphalt is frequently laid on grades of 6 or 7%, while in Scranton, Pa., part of a street having a 12½% grade is so paved. It is said that this pavement was laid more to keep traffic away from the street than to facilitate it. but that in this respect it has not been altogether successful, as the public insist upon using it.

The question of durability occurs next, and the different kinds of pavement which may be considered for city streets may be rated as follows, it being assumed that the traffic is not excessively heavy:

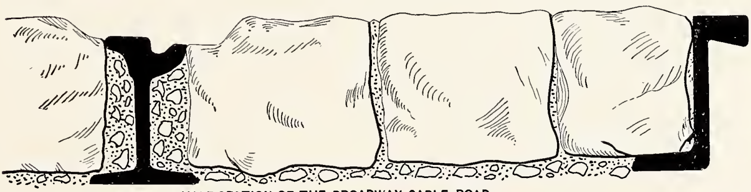
Kind of pavement.	Life in years.
Best granite block on concrete	30
Granite block laid on sand	20
Belgian trap	20
Cobblestone	18
Asphalt—rectangular block	15
Best wood—triangular block	10
Vitrified brick	12
Macadam	8
Cedar block, round on sand	5

Cobblestone is given a life of 18 years, and if subjected to much traffic it will not last longer. Its usual life, if well laid, is greater than this, for the reason that no one will drive over it if there is any other street differently paved which can be used. Rectangular wooden block pavement is rated at ten years, but this is not based upon experience had with it in this country, and is considerably less than is claimed for the Australian hard words.

The selection of the kind of material to be used in paving any particular street when the character of its traffic and other governing considerations are known was fully discussed before this Club by Mr. Geo. W. Tillson. To this paper and to the ingenious and original table prepared by him as published in the *Proceedings* of 1898, I will refer you without dwelling further upon this subject.

Reference must be made to that *bête noir* of the engineer of street pavements, the ubiquitous surface railroad track. The difficulty of keeping our roadways in good condition is greatly increased by the presence of these tracks. They are a necessity, however, and the development of our cities depends more upon efficient systems of transit in the streets than upon any other one thing. So it is better to get along amicably with the railway corporations, if possible. It has been hard to make them understand that they have any responsibility as to the condition of the pavement between and along their tracks. In the days of horse cars of light weight almost anything would do for the track spaces, and a pavement rough enough to give

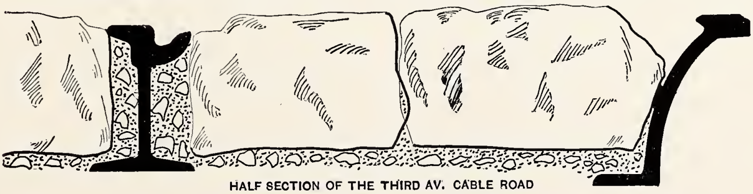
Track Construction, Court Street, Brooklyn, New York City.



HALF SECTION OF THE BROADWAY CABLE ROAD

OLD HORSE CAR RAIL ON STRINGER

SECTION OF CABLE TRACK IN ASPHALT PAV'T



HALF SECTION OF THE THIRD AV. CABLE ROAD

Sections of Track and Pavement.

the horses a good foothold in starting the cars was all that was desired by them. With the introduction of heavy electric cars the track had to be strengthened, and the companies are now building in the most permanent manner possible. The 9-in. girder rail has superseded the flat rail laid on wooden stringers. Steel ties are being substituted for wood, and the rails are sometimes laid on beams of Portland cement concrete, without any ties, and are kept to gauge by tie-bars between them, or by angles secured to the lower flange. Grooved rails are gradually being substituted for side and center bearing, although the companies have generally strongly opposed them until compelled to use them, when they have discovered that there was no objection to this section from the railroad standpoint. Along the best built tracks in New York City, and where the pavement has been laid with the greatest care, the ruts will develop within a few months, while the condition of the track pavements in connection with some of the old stringer rails was simply disgraceful.

This has been but a superficial and very general view of the subject of street paving,—nothing more ambitious than its title would indicate, —"some notes on paving material and their use." It may have suggested more than it has expressed, and drawn attention to the increasing importance of this branch of municipal work, long left to so-called practical men who were entirely without scientific training. Really technical work along these lines is only beginning. The trained engineer is each year being called upon to take a more important part in the renovating and rebuilding of our city streets. He is now frequently placed in administrative positions which were formerly considered political. His opinions and reports are treated with greater respect.

A vast amount of such work remains to be done, not only at home, but especially in the tropical cities of the islands which have recently been added to our domain. The first lessons to be taught their people are cleanliness and a proper regard for sanitary conditions, and these are no more dependent upon a wholesome water supply and good drainage than upon well paved and thoroughly cleansed streets. I doubt if the former are such potent factors, as well paved and well cared for streets furnish an object lesson which they who run may read.

DISCUSSION.

The President. The PRESIDENT.—Mr. Lewis's paper is now before you for discussion, and I think, as probably the most interesting part of the paper was on asphalt streets, and we have with us to-night a representative of the company mentioned by Mr. Lewis as having laid the first bituminous pavement in the world, I will ask Mr. Cranford to say something about asphalt pavements.

Mr. Cranford. Mr. W. V. CRANFORD.—Mr. President and gentlemen: I must confess to some trepidation when Mr. Lewis called me up this morning about 11 o'clock, and asked me if I wouldn't give you an account of the early history or origin of bituminous concrete pavements in this country. I find, however, that Mr. Lewis's very excellent paper rather confines my account of this history to the very short period extending between 1865 to 1870. About 1865 an uncle of mine, Mr. H. L. Cranford, was engaged in the coal mining business in Lockhaven, Pa., and there became acquainted with a man named Scrimshaw, who was a visionary sort of a fellow, without any particular business, and one of these men that are to be found in nearly all communities, depending on his wits for a living.

Like almost all towns at that time, especially small towns, Lockhaven lacked any pavements. There were simply dirt roads, largely clay, which in wet weather were almost impassable, especially to foot passengers. This man Scrimshaw, in hunting around for ways and means to make a living, devised or discovered what has since become known as Scrimshaw pavement. It was used in Lockhaven solely for making crosswalks across the streets, and was made at that time of coal tar and sand, mixed with coal dust from the coal mines. This uncle of mine observed how these substances acted under varying weather conditions and wear, and called my father's attention to it, who went to Lockhaven to examine samples of work that were there and get into communication with Mr. Scrimshaw. The result was that the Scrimshaw Paving Company was organized, and an effort made to introduce that class of pavement into the City of Brooklyn.

Mr. Cranford soon interested Mr. J. J. Stranahan, at that time one of the Park Commissioners and one of Brooklyn's leading citizens, in this method of laying pavements, and obtained his consent to lay what was probably the first piece of bituminous asphalt, or bituminous concrete pavement, laid in this country. This was laid in Prospect Park, in the East Driveway, just to the south of where the boathouse now is. Relics of that pavement were there until a few years ago, when the whole road was re-macadamized.

The following year Diamond Street, a view of which you saw on the screen, was paved by Mr. Cranford. At that time he used simply

coal tar as a foundation, and laid about 3 ins. of binder course, which was composed of gravel running from the size of an egg down to the size of a hazel nut. That was rolled by hand with stone rollers. Then came a wearing surface of sand and coal tar. The coal tar which we used at that time was obtained, I think, from the Citizens' Gas Company in Brooklyn (and the gas that they made was from English coal), of uniform quality and good material for making pavements, no other flux being used, except to get the tar to a consistency which would be elastic and durable. Mr. Cranford.

I think it was in 1869, after that, that a portion of Bedford Avenue was paved in the same manner. There we used a somewhat different method of procedure in the foundation. The street was graded, and we used cobblestones there. The interstices between the cobblestones were filled with gravel, and the surface was covered with sand and rolled by hand and horse-power at that time. About the time that Bedford Avenue was paved, the supply of tar made from this kind of coal became exhausted. We then got a very variable quality of tar, and we never could tell what one cargo was going to be, hard or soft, or whether it would make a good or a bad pavement. As a consequence, this kind of pavement fell into disfavor, and it was at this time that the problem of finding some substitute which would be more uniform was taken up. Then it was that asphalt came into use. Mr. Lewis's paper discussed the period after this, and I fear that my remarks on the old bituminous pavements will not add very materially to the discussion.

The President.—About a year ago one of our members gave us a long talk on asphalt pavements. I do not suppose he told us all he knew at that time, and we happen to be aware that he knows a few more things upon the same subject. Mr. Vail has spent many months in Europe and has had an opportunity to see for himself some of the methods of paving there, and knows something about what the folks over there think on the subject of pavements. We would like very much to hear from him on those subjects. The President.

Mr. F. N. Vail.—Mr. President and gentlemen: I am afraid that I have not very much to add to Mr. Lewis's paper on the subject of asphalt, although I noticed last year in Scotland and elsewhere a rather interesting revival of the tar pavements. A new material, or what they consider a new material, called tar macadam, is being used quite extensively for light-traffic streets. It is composed simply of sand, gravel and broken stone, running from dust to about ½ in. in diameter, and coated, I think, with tar. Of course, the tar they get there is of the kind that Mr. Cranford said was used in the earliest pavements. It is a very good quality of coal tar pitch, used by chemical workers there in the refining of the crude material which they get from the gas companies. The pavement is laid by a man named Walker, who has a Mr. Vail.

Mr. Vail. large chemical works. He has introduced it under the title of Walker's Tar Macadam.

That pavement, which is practically the same as the first bituminous pavements laid in this country, has been introduced in the last three years into Great Britain, and is being used quite extensively by small towns, and even by some large towns for alleys and residence streets with light traffic. Some give fairly good results. It is laid to the depth of about 6 ins., the top inch being rather finer than the under 5 ins.

Outside of that I did not notice very much in regard to the method of laying asphalt there, which is practically the same as the method used here for laying rock asphalt, and which give very good results indeed. London asphalt pavements, particularly, are standing traffic which, certainly, no asphalt pavements in this country have been expected to stand. Whether they could or not is another question, although I doubt myself whether our asphalt pavements would stand the heavy traffic that rock asphalt does.

I would like to emphasize what Mr. Lewis said in regard to the superiority of their stone pavements. There is no comparison whatever between them, particularly as regards depth, and I am of the opinion that the stone is of a harder quality and more fit to stand traffic than the granite used here, although as to that point I am not quite sure. They lay a 6-in. concrete foundation as a rule. In some cases, I think, they lay 8 ins., and they smooth that foundation over with about ½ to 1 in. of mortar, composed of sand and cement, without any stone, and the surface is absolutely smooth. They then place their blocks as closely as they possibly can on the concrete, without using any sand, as that is not necessary. A pavement of that kind stays exactly the way it was put down until the stones become so round as to be dangerous. Then they remove them as a rule, and use them upside down on a less important street. In some cases, where rectangular blocks have been used, they run in lengths of 10 to 13 and 14 ins., and they break the blocks in two and dress them to a cube. Those stone cubes are used on streets that are not very important, and I think the very best practice in London is to use cubes, as Mr. Lewis said, in the first instance, though in Glasgow they did not. They used the rectangular blocks in the first place.

In regard to the street railway track, I think that they have in a measure solved the difficulty over there, in this way. I cannot at present remember any street on which there is a railroad track which is paved with any other material than stone, with the exception of one street, which was paved last year in Glasgow with asphalt, and in that case we put a row of stone on each side of the rail. But their stone block pavements, even those that have seen ten or twelve years' service on very heavy traffic streets, show no sign of rut next the rail,

nor any unevennesses. That is partly owing to the fact that up to the past couple of years only horse cars have been used there, and the rail has not had to be disturbed to fix joints as often as is necessary here. There they lay the rail, as a rule, directly on the concrete—that is the present practice in Glasgow—using a rail with a rather wide base, and then putting on another layer of concrete, which covers up the foot of the rail and runs up on the web side. Then they lay their stone, but on each side of the rail they alternate a stone block with a chilled steel block casting 4½ ins. square, and roughened on top to prevent slipperiness. The block is cast hollow, in order to save material. The alternating stone block is of the regular size that they use on the rest of the street. That, with the width of the rail, gives you practically a steel construction. I do not know the width of the rail, but suppose it is about 3½ ins., including the top and the groove, and then 4½ ins. on each side gives you 9 ins., say a 12-in. strip. That prevents a rut from forming directly next to the rail, and, consequently, prevents vehicles from following in that rut after it is formed and making the rut worse every time a wagon turns out. It would appear possible that a rut would form on the outside of that steel block, but that does not seem to be the case. Certainly their pavement comes up flush to the rail, and shows absolutely no sign of groove on either side. That I noticed on all the street railways in Glasgow, and what few there are in London, and, also, in Edinburgh, where in some cases they use the steel block, not alternating the stone block, but touching each other all the way down the rail. I think that that idea is worth considering, and, possibly, might be worth trying on a small scale in some towns. It wouldn't cost very much to make the castings, and the pattern could be obtained from Glasgow. There they don't think of putting down a pavement where there is car traffic without using it. Mr. Vail.

Mr. George W. Tillson.—I do not know that I can add anything that will be of any particular interest, except, possibly, one thing. Within the last few days there has been called more particularly to my notice than before a new bituminous pavement, which, if it is as successful as the promoters seem to think that it may be now, may do probably what would seem a very strange thing—bring us back from asphalt to coal tar pavements. Within the last four or five years a company has been organized to use what they call "Asphaltina." It is made of coal tar, resin and sulphur. Ten thousand yards of this pavement has been down in Worcester, Mass., for four years, and a representative of the company told me that it is in as good condition now as it was when it was laid. Mr. Tillson

Advocates of such a pavement as that have a great deal to overcome in establishing it, because the people who are engaged in the asphalt business, and all city officials who have had anything to do with asphalt, or bituminous pavements, are very much prejudiced against

Mr. Tillson. any material that contains coal tar, on account of the ill success which the original coal tar pavements have had. As I said before, if this is a success and we do come back to laying coal tar pavements—although to be candid about it, I do not think it is hardly probable—it would seem very strange.

It may possibly be of interest to know, while bituminous pavements have been laid in this country now for nearly thirty years, how much of it has been laid in the last eight or ten years. I shall simply give a few figures, and give them very quickly, as to the pavements of Philadelphia, New York and Brooklyn.

In 1884, the pavements of Philadelphia consisted of a little over 9 000 000 yds. of cobblestone, 654 000 yds. of granite, and 25 000 yds. of asphalt. I am giving the figures in round numbers. This made 93% of cobble, $6\frac{2}{3}$% of granite and $\frac{1}{3}$ of 1% of asphalt. At the present time, Philadelphia probably has the most paved streets of any city in the country, excepting Greater New York itself. On the first of January, 1898, it had, in round numbers, 1 000 miles of paved streets. Of that 1 000 miles the asphalt was nearly 200 miles, where fourteen years ago it had only 25 000 yds., which was about $1\frac{1}{2}$ miles. Of granite block it had 344 miles; while the granite that I gave you for 1884 was, I think, Belgian—that is square block, but made of granite. That shows the amount of new pavement in Philadelphia.

In New York City proper, that is, Manhattan and the Bronx boroughs, in 1890 there were 100 miles of granite; 131 miles of Belgian; 67 miles of what they called specification trap—that is, of the oblong blocks, which are practically the size of granite blocks; 25 miles of square granite—that is Belgian; 25 miles of macadam, and of the rest, a very small amount, $3\frac{1}{2}$ miles of asphalt. Now they have about 143 miles of asphalt which they have laid within the last eight years. They have increased from 3 miles to 143 miles. The total mileage of pavements in Manhattan and the Bronx boroughs now is about 550, and with the amount that we have in Brooklyn, together with Queens and Richmond, will bring it up for Greater New York about 1 720 miles, including all macadam.

In Brooklyn in 1890 we had 280 miles of cobble, 22 miles of Belgian, 55 of granite, and 8 of asphalt. At the present time we have 238 miles of cobble, reduced from 280, 45 of Belgian, 113 of granite, and 66 of asphalt (while of the latter we had about 9 miles in 1890), 73 of macadam, and a trifle less than 4 miles of brick.

The point that I wish to make is that nearly all of what we to-day call the improved pavements of America have been laid in the last ten years. Our first granite on concrete in this country has only been down about ten years.

Mr. Strachan. Mr. Joseph Strachan.—I would like to ask Mr. Lewis what success the Department of Highways has had in laying asphalt on cobble as a

foundation. I think that Montague Street a number of years ago was paved in that way. I know that portions of Hancock Street were also paved in that way, and this latter street seems to be in pretty fair condition to-day, with the exception of some ruts that are due to the laying of a sewer. Mr. Strachan.

Mr. N. P. Lewis.—I will say that I consider Brooklyn has had very excellent results in laying asphalt over cobblestones. Up to four years ago we never thought of doing anything else, and it was really only when we commenced to pave streets with asphalt which had been laid with cobblestone within the last fifteen or twenty years, where boulders had been used of such a size that they could not be removed from the street without breaking or blasting, that we found that the unevenesses were so great, and required such a large amount of binder, that we broke up these large stones and made concrete of them. We paved State Street two years ago over the cobblestone with excellent results; but when you have got to take up the entire roadway where there are these enormous stones, and relay it, I do not think it pays. Our practice is now to remove most of the cobble, but where we find stone block we lay asphalt over it. We do not take up stone blocks and substitute concrete. Mr. Lewis.

Mr. H. B. Seaman.—I would like to ask Mr. Lewis in regard to using large blocks, whether the larger blocks are not used where we have inferior subsoil. They use such block in New Orleans, and I imagine it may be the case in some European cities. Is that not the real reason for its use? Mr. Seaman.

Mr. N. P. Lewis.—I think it was originally, Mr. Seaman, but of course, with improved pavements, we ought to lay a concrete foundation under the blocks. Large stones are so extremely slippery that it is certainly better to take chances of a little settlement, I think. Where the soil is seepy we can certainly by putting in 4, 5, or 6 ins. of sand or gravel, get a sufficient wearing surface for rectangular block, even if that block is 8, 9 or 10 ins. long, and only 4 ins. deep. In the old pavement on Broadway, back in the thirties, or later than that, extremely large blocks were used, 8 x 12 ins., and even more than that. Mr. Lewis.

Mr. Joseph Strachan.—What is the approximate saving per square yard between laying asphalt on a fair cobblestone pavement, and laying it on a concrete foundation ? Mr. Strachan.

Mr. N. P. Lewis.—Well, if all the pavement has to be taken up, and relaid, as it usually has, the difference in laying asphalt over the old stone pavement will probably be 35 cents per square yard. That allows about 25 to 30 cents per square yard for taking up and relaying the old stone pavement; while if that were removed and broken up into concrete, the corresponding cost of concrete would be 65 cents per square yard. Mr. Lewis.

Mr. Strachan. Mr. Joseph Strachan.—Do you not sometimes simply brush off the cobblestones with wire brooms, and clean out the spaces between the stones ?

Mr. Lewis. Mr. N. P. Lewis.—Not of recent years, in my experience in the Department. I do not think we have ever laid a street with asphalt where we have relaid less than 60% of the cobblestone. We got off about as easily on Carlton Avenue as we did anywhere, and I think we did save half there. We put in 2 or 3 ins. of extra binder, for which we had to compensate the contractor, in order to get any sort of cross-section. It really cost us about as much as if we had relaid them. We thought, however, that we were getting a better job by using binder, and not disturbing the pavement, which certainly had a solid foundation after being there thirty years.

Mr. Tenney. Mr. W. R. Tenney.—I would like to ask Mr. Lewis if, in his investigation of pavements in foreign cities, he looked into the traffic in those cities, and if he did not find that the traffic was very light as a rule, and that the use of those large stones was probably on account of the smoother surface, and not due to anything in the shape of the foundation. I have always supposed they were used for that reason, as the traffic in most continental cities is very light.

Mr. Lewis. Mr. N. P. Lewis.—I have always regarded that class of pavements in some European cities as simply conservatism of the old world in laying the same kind of pavements—in fact the only kind of pavements people knew anything about at that time. Small blocks are better. In Southern Europe they haven't found that out, but they are using now what they used thirty or forty years ago. I don't believe it is because traffic is light, but because all pavements were laid there in that way. Either traffic isn't great enough, or they are not progressive enough to put on anything better.

Mr. Tillson. Mr. George W. Tillson.—I think, Mr. President, that that is the real solution of the problem. It has just been the natural development of the paving block. All of the first pavements, of course, were laid with stone of the size that came out naturally. Then they cut them square, and of pretty good size, and it has been the tendency of the paving block to grow smaller. London to-day is probably using the smallest granite block of any city in the world. Their present granite specification calls for block that shall not be more than 3 ins. wide and 9 ins. deep. I do not think the question of foundation has anything to do with it. The first pavement laid in New Orleans was cobblestone, and was very successful, and they were quite surprised to find that cobblestone would stand as well as it did with that soil.

Mr. Vail. Mr. F. N. Vail.—I noticed a case in point in Sheffield where all the streets were paved with the regulation stone, except one down in the manufacturing district—a perfectly flat street, where I found very large stones used—I should say in some cases, possibly 3 ft. square. That

street was pointed out to me by the City Engineer as one we could experiment with if we wanted to, and I was a little suspicious of it. I asked him what kind of traffic they had. He said they had very little horse traffic over it; that they hauled heavy castings by means of traction engines—about 40 tons. I told him I did not want it; but he told me these large stones were the only thing they could keep on the street at all—blocks running from 2 to 3 ft. square and about a foot thick that they put down on top of the concrete. It made a very smooth, nice street. Mr. Vail.

The PRESIDENT.—Isn't it a fact, Mr. Lewis, that most brick streets get a bad reputation from chipping a great deal during the first year? The President.

Mr. N. P. LEWIS.—I thought at the end of three months that everybody's reputation who had anything to do with the first brick pavement laid in Brooklyn would be ruined, and that the brick would all go to pieces. But after the chipping had gone on for three months it apparently stopped, and stayed in about that same condition for the next two or three years. Our experience with brick has been, I suppose, approximately that of other cities. It is not such, however, as to warrant us in thinking that we can lay it on any street where there is going to be any traffic at all. Mr. Lewis.

Mr. D. F. CARVER.—I have often thought that below the surface of granite and asphalt pavements there must be a considerable amount of sewer gas. I have observed that this gas comes out through the cracks in the stones, unless the pavement is absolutely air-tight. I have often wondered whether the asphalt pavement had a tendency to force that sewer gas off into the houses of the abutting property owners. Mr. Carver.

Mr. N. P. LEWIS.—I do not know whether I can answer that question or not. I have not heard of any complaints of this kind after an asphalt pavement has been laid. Mr. Lewis.

The PRESIDENT.—Isn't it a fact that the houses are about as well protected by their watertight cellar floors and walls as the streets are by the asphalt covering, and that the escape of gas would have to be through the yards, etc., and not inside the houses. The President.

Mr. N. P. LEWIS.—The area inside the curb line, which is generally unpaved, would be amply sufficient to allow it to get out. Mr. Lewis.

Mr. E. J. FORT.—With regard to the laying of asphalt pavements next to the street railway tracks, I believe that the reason for a good deal of the rut on a street railway track is caused by the fact that the asphalt is finished altogether too low. When it is raked out before the rolling is done, it is raked almost down to the level of the track. The roller comes along and runs back and forth on the rail, and the asphalt next to the rail gets little or no compression. I noticed a little piece of asphalt laid on Court Street by the Brooklyn Alcatraz Asphalt Company, where, either by accident or intention, the surface Mr. Fort.

Mr. Fort. was finished about $\frac{1}{4}$ in. above the rail, and so far it has stood remarkably well. I believe a great improvement would be made in laying all asphalt in that way, finishing the asphalt both on the inside and on the outside of the rail fully $\frac{1}{4}$ in. above it.

Mr. Cranford. Mr. W. V. Cranford.—The compression done next to the rail is done much better by tamping by hand than it could be by putting a 15-ton roller on it.

Mr. Fort. Mr. E. J. Fort.—In many places immediately after laying the pavement, the surface of the asphalt is $\frac{1}{8}$ to $\frac{1}{4}$ in. below the rail, and the rut is already started.

BROOKLYN ENGINEERS' CLUB.*

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A HALF CENTURY OF SANITATION.
(1850-1899.)

BY WM. PAUL GERHARD, M. B. E. C.

PRESENTED FEBRUARY 9TH, 1899.

We shall soon be standing at the threshold of a new century. This seems, therefore, a fitting and proper occasion for making a halt in the hustle and bustle, so usual in our modern business and professional life, to consider one out of the many magnificent achievements of the century which is now drawing to a close. A wanderer on a long journey likes to rest occasionally to look back over the road which he has left behind him and to contemplate the path which lies before him. I shall ask you to-night to pause, like the traveler, and to cast with me a retrospective glance over the past, and, particularly, over the second half of the nineteenth century.

Our century will be described by future historians as the era of wonderful practical progress of mankind in the application of the sciences to inventions. Indeed, the progress of this century, in the industries and the applied arts, as well as the changes in the mode of our living, have been so vast, that only the older living people can realize thoroughly what stupendous results have been accomplished in this comparatively short period of history.

While the use of steam in the steam engine originated with James Watt near the close of the eighteenth century, all important applications of steam were inaugurated after the beginning of the present

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

century. Think, for a moment, what the railroad and the locomotive have done for mankind, what immense progress in speed, safety and comfort of traveling has been achieved, how completely travel on land has been revolutionized, from the slow stage coach to the mile-a-minute trains, how a similar progress has taken place, step by step, in steam navigation, how both have served to extend trade and commerce, and to spread knowledge; how nations have been brought closer together, how famines have been reduced in severity and wars shortened in duration, by these improved means of communication on land and on water.

Consider the truly wonderful way in which the conveyance of thought has been revolutionized by the railway and ocean mail system, by the electric telegraph, by the telephone and the submarine cable. Contemplate the changes which have occurred in the modes of obtaining fire and light, the radical departures from old-time methods of interior and outdoor illumination, by gas lighting and by the electric light. Look at the numerous now practically available inventions in labor-saving machinery, of which I will only mention the agricultural implements and machines, the sewing machine, and more recently the typewriting, type-setting and type-distributing machines. And again in the science of light, how wonderful are the inventions of photography, of spectrum analysis, and the discovery of the Röntgen rays!

These marvelous accomplishments, and a great many more which I have not the time to mention, belong, every one of them, to the nineteenth century. They constitute one reason for our superiority over former generations, for they have enabled us to make better and more extended uses of Nature's powers in the interest of mankind. It is not with these, however, that I wanted to occupy your attention for a brief while to-night.

Many of the discoveries, inventions and engineering achievements named belong to the first half of this century. Its second half has been distinguished, perhaps more than in any other respect, by the birth of public sanitation and of applied sanitary science. In saying this I do not mean to convey the idea that there had been no sanitation before. It is well known that many of the nations of ancient history practiced sanitation, and, with their limited means, tools and knowledge, erected many great works which served the interests of public health. The Hindoos and the Parsees were practical sanitarians;

to them both water and soil were holy, and pollution of either was a punishable offence. One of the teachings of Zoroaster was that the purity of flowing water-courses should not be defiled.

The Romans built gigantic aqueducts, canals and works for the supply of water to the cities, both at home and in their provinces. Many ancient cities had a system of sewers. Some of the cloacæ of Rome have been preserved, and are even used at the present day. History records also that the Romans, the Assyrians and the Babylonians made use of tubular pipes for drainage purposes. Grecian houses had sanitary conveniences and bathing arrangements, and the public baths of Rome, built during the time of the Emperors, were magnificent and costly structures devoted to recreation, personal cleanliness and health.

Following this period of advanced civilization, however, came an era of decay and retrogression. During the Middle Ages all arts and sciences declined, and with the decay of civilization sanitation was more and more neglected, until it became a lost art. Personal cleanliness was not thought of, the practice of bathing was given up, clean clothing became almost unknown, in fact, owing to the ascetic practices of the monks, uncleanliness of the body became identical with sanctity. During this dark period of history, happily gone by, knowledge was largely confined to the priests and monks, who purposely kept the masses of the people in ignorance, and who exerted such a dominant influence upon them that their example of uncleanliness was blindly followed. In this period of sanitary neglect and decay the noisome cesspool appeared, being first used at monasteries, subsequently at feudal castles. In both classes of buildings the sanitary appliances are said to have been of the most primitive kind. The cities and towns of this period likewise presented the worst imaginable appearance of sanitary neglect. It is no wonder that plague and pestilence made their appearance in Europe in the fourteenth and fifteenth centuries; that, as the inevitable consequence of disregard of sanitation entire populations were decimated, and that the death rates of towns became appallingly high.

In order to more thoroughly appreciate the benefits due to modern sanitation, let me picture briefly the condition of cities and towns a century or more ago, as we find them described by historians. Nearly all cities were badly overcrowded, this being in many instances due to

the fact that the fortification works prevented the growth or development of a city beyond its walls. The houses were low, dark, ill-ventilated and unsanitary, and often full of foul air. The floors were of earth, covered with rushes, which were generally saturated with filth. Cesspools were commonly located underneath the houses, or placed in the ill-aired courts in the rear. The shops where the people carried on their trades were also generally unhealthy. The streets were narrow, darkened by the overhanging stories of the buildings, and unpaved, except, perhaps, the main town thoroughfares, and these were paved with the coarsest quality of cobble stones. No sidewalks existed; pedestrians were compelled to walk through mud and dirt; slops and solid refuse from the houses were thrown upon the streets, generally at night time; no attempt was made to remove this filth or to clean the streets by any system of scavenging. The crevices of the pavements retained the solid filth, while the liquid scaked into the ground and contaminated both the subsoil and the public wells, which were the only means of water supply available to the inhabitants.

Large heaps of mud, dirt and refuse accumulated in the streets, and hogs were running about in the public squares. Open water courses, flowing through the towns, and serving at first as sources of water supply, soon became polluted by sewage, until the fetid emanations compelled the authorities to arch them over, and thus convert them into objectionable sewers of deposit. The water used in the houses was generally drawn from wells located in the public squares. As it had to be carried by hand, it was used but sparingly, and the ablutions of our forefathers were usually confined, so we are told, to the face and the hands, while frequent change of underwear was not yet practiced, owing to the expense of the linen and cotton garments, and the cost and trouble of washing. Much sickness and unhealthiness were also due to the poor quality of the food available to the lower classes of the population. Because of the unimproved and generally bad condition of the country roads, fresh supplies arrived at the towns irregularly and always at long intervals. There were, finally, no public markets, no public slaughter houses, and no sanitary control of the food supply.

Such was the state of sanitary neglect which cities presented one or two centuries ago! With the commencement of this century a better era began, but the large and systematized public efforts for the improve-

ment of the sanitary condition of communities date only from the beginning of the second half of our century. It is also true that the earlier sanitary works, such as water works and town sewers, were rather the outcome of necessity and were built to fulfill requirements of comfort and convenience, to provide necessary commodities, or to guard property against conflagrations. The health point of view, which in such works is of prime importance, was not, as a rule, considered or appreciated. It was only with the advent of modern sanitary science that it became more generally recognized that the creation and the maintenance of healthful conditions in a community depend to a great extent upon the carrying out of large and important municipal sanitary works, assisted in turn by individual efforts of householders to establish sanitation in the dwelling houses and places of work.

Three professions have chiefly contributed to secure the grand results, of which, at the close of this century, we may be justly proud, viz., the engineer, the chemist and the biologist. If in the following I say but little about the valuable achievements in sanitary science which are the outcome of the labors of the chemist and the biologist, it is because my paper to-night is addressed to a body of civil engineers, and also because, being myself an engineer, I am little qualified to speak with expert knowledge of the work and the successes of the other professions mentioned, invaluable as they have been to the sanitary engineer in his recent practice. I shall confine myself therefore, to a brief and general review of the work done by engineers in the interest of sanitation.

Speaking generally, works of engineering relate first, to commerce and transportation or communication by land or water; second, to agriculture; third, to manufacturing and mining; fourth, to buildings and architectural construction; fifth, to public health, and sixth, to warfare. Ours is an age of specialization in all professions; a man can only distinguish himself by concentrating his energies in a special branch. We, therefore, find nowadays a very large number of specialties or branches of engineering, but it will be found that the scope of the work of all of them comes under one or the other of the above mentioned divisions.*

*See Wm. Paul Gerhard, *Sanitary Engineering*, 1898.

Sanitary engineering is that branch which is devoted to works by which the public health of communities or nations is promoted and disease prevented; it is one of the recent and, in many respects, most important branches of civil engineering; it originated practically, and certainly developed entirely, in the great epoch of history embraced in the past fifty years. Its importance is characterized by the utterance of a prominent statesman that "the greatness of a country is dependent more than anything else upon the physical constitution of its inhabitants, and everything which is done to improve the state of public health forms the foundation for the strength, the power and splendor of a nation" (Disraeli, Earl of Beaconsfield).

The sanitary engineer, guided by the results of the researches of the biologist, the chemist and the sanitarian, carries out into practice, in designing public sanitary works, the requirements of sanitary science, and thus he creates sanitation. Systems of sanitation originated from the time when sanitary science and the germ theory of disease taught us that there are preventable deaths and preventable illnesses arising from polluted water, contaminated air, bad food, impure soil, from filth accumulations and general neglect of cleanliness. The true foundation for all works of modern sanitary engineering is the now well-established fact that pure air, water, soil and food are the chief essentials of personal as well as public health.

A pure and abundant water supply constitutes one of the great sanitary requirements of modern cities, and the problem how to provide the same belongs to both the hydraulic and the sanitary engineer. That water is a necessity to both man and beast, even more so than solid food, was known to the early nomadic races, who located their tents near springs or rivers. Water is required for ablutions and personal cleanliness, but likewise for the maintenance of cleanliness in the houses, in streets and public squares; it is necessary for sprinkling thoroughfares, thereby avoiding unwholesome dust. It is also required in the water-carriage system of sewerage, for flushing the sanitary appliances of buildings and the street sewers. Many of the cities of ancient history were provided with a system of water supply, but during the middle ages no water-works were built, and in fact the works of the older cities were permitted to decay. In our century water-works construction received a great impetus particu-

larly after the closing up of town wells, known to have been the cause of epidemics by reason of being polluted from cesspools, privies or leaky sewers. The rapid growth in the number of cities and towns having a public supply dates from the time when the art of casting iron pipes, which originated at the close of the last century, was perfected. Cast-iron water pipes were used in London for the first time in 1809, and consisted of pipes only 3 and 4 ft. long, and not larger than 12 ins. in diameter. Before that period, wooden logs were often used for supply mains. According to Professor Merriman there were only five public water-works in the United States prior to 1800, and prior to 1851 there were only 68 water-works. In 1880, 629 water-works systems were in operation; in 1888, 1,598; in 1890, 2,037, and, according to the Manual of American water-works for 1897, there were in existence in the United States in that year 3,196 works. On the Continent of Europe, likewise, all central water-works systems originated practically since 1850. These figures speak eloquently for the fact mentioned heretofore that the era of sanitation began with the second half of the present century.

No town or city can expect to grow or prosper without a public water supply. Once water is introduced, all town wells should be closed and the connections with the houses made compulsory. When cities begin to expand in area and population, or when they become thriving manufacturing centers, additional works and more abundant supplies are often required. Water introduced under pressure is used more lavishly in American than in European cities, which is partly due to our generally wasteful habits. Simultaneously with the problem of additional supply arises the question of how to check the waste of water without in any way reducing the sanitary advantages derived from the system. Often the source of supply becomes slightly polluted, and epidemics of typhoid fever warn the authorities that works for the purification of water are required. The prevention of contamination and the purification of a water supply on a large scale are two great sanitary problems which only recently have attracted public attention. But few cities of the United States have so far arranged filtration works, consisting either of natural filtration by filter galleries along the banks of rivers, or of artificial slow filtration in filter beds of sand, or of mechanical filtration through batteries of filters which generally operate under high pressure and pass quickly

very large volumes of water. Owing to the very satisfactory results obtained where water derived from open streams is purified by filtration, particularly in the reduction of the death-rate from typhoid fever, this great sanitary problem will undoubtedly command a large share of the attention of municipalities during the years to come.

In the past fifty years nearly every large city of both Europe and America has either introduced a water supply or enlarged its works. Paris has a double system of supply, river water being designated for public use, while water for drinking and other domestic uses is conveyed to the city from distant springs and mountain sources by means of large aqueducts. Some of these works were completed in 1865, others in 1874, and, quite recently, another additional supply was completed in 1894. The City of Hamburg derived its water supply from the River Elbe, and after the severe epidemic of cholera in 1892, caused by polluted water, established large sand filter beds which have been in operation since 1893. Vienna conveys its supply of pure mountain spring water from the Alps, a distance of 80 miles. As a result of the violent cholera epidemic, a new public water supply for Naples was completed in 1885, and has materially bettered the sanitary condition of the city. Since years, the question of a more abundant supply is being agitated in London, the scheme proposed being to bring the water to the metropolis from Mid-Wales.

It is only a few years since New York completed the second aqueduct, which increased its daily supply by many million gallons, and a new and extensive storage reservoir is now in course of construction at Quaker Bridge. Yet even here we learn of projects contemplating a supply to Greater New York and the towns of the Hudson River valley from the Adirondack regions, while still another engineering project proposes the conveyance of water from the Ramapo River in New Jersey. Instances are multiplying rapidly where large towns find themselves under the necessity of spending vast sums of money to tap distant uncontaminated sources of water supply. Owing to the contamination of the Hudson River water by the sewage of cities located up stream, the City of Albany is now obliged to construct large sand filtration works. St. Louis has for many years suffered from insufficient capacity of the water-works, and not less from the muddy condition of its water; new works have now been put in operation and filtration of the river water is contemplated. In this connection men-

tion must be made of the valuable researches on sand filtration of water, made by the chemists and biologists of the Lawrence experimental station of the Massachusetts State Board of Health, and of the still more recent Louisville, Pittsburgh and Cincinnati experiments on mechanical pressure filters.

Progress in sewerage works has been much slower than in works of water supply. This can be, in a measure, explained by the fact that taxpayers are nearly always willing to pay a small annual tax for water, and hence the financial success of such a scheme is rarely in doubt, whereas a sewerage system does not yield an annual revenue, but, on the contrary, causes sometimes large operating expenses, as, for instance, in cases where the sewage must be treated before discharge into a water course. It is therefore a much more difficult matter to induce communities to introduce a sewer system, but on the other hand it is a well-known fact that the introduction of a public water supply has generally been a stimulus to sewer construction.

Sewers were originally built with a view of removing storm water from the street surfaces; the introduction of liquid household wastes followed only incidentally, and the removal of human excreta by water carriage is of still more recent origin. While the construction of sewers by civil engineers dates from the beginning of this century, and even from earlier times, the sanitary features and functions of a sewer system and the benefits to public health derived therefrom have been but recently studied and recognized. Prior to the year 1850, few, if any, cities had a regular system of sewerage, built in accordance with a well-studied general improvement plan, though we do find in the older cities underground conduits, built by unskillful mechanics in a haphazard manner, without any attempt to make them water tight or to construct them properly, as conduits for the removal of foul water and excrements should be built. Before the year 1815 the introduction of fæcal matters into the sewers of London was prohibited; it was there made compulsory only in 1847. In St. Louis the former rule existed up to 1842, while in Baltimore and Paris this is the case even at the present day. The use of modern pipe sewers was advocated first by Edwin Chadwick in 1842, and they were actually used first in modern times by John Roe and Sir Robert Rawlinson in England.

Since 1850 the organized efforts of city boards of health have been directed nearly everywhere against the continuance of cesspools and privy vaults in cities, and as the best sanitary substitute the construction of sewers for the removal of household wastes and excreta was urged. After the great conflagration in 1842, Hamburg was the first city of Germany to introduce a well-designed sewerage system which was built under direction of the elder Lindley. Dantzig was sewered by Wiebe, assisted by Baldwin Latham, in the years 1869–71. Then followed Berlin in 1870–1880 under plans by Hobrecht, and more recently Frankfort-on-Main, the well-built sewer system of which was planned by W. H. Lindley, the son of the above-mentioned English engineer. The first modern main sewer was built in Paris in the Rue de Rivoli, in 1851, and in 1856 the new sewer system, planned by Belgrand, was adopted, which comprised several large intercepting sewers. A well-known feature of many of the Paris sewers is their construction as general subways for water and compressed air pipes, and telegraph and telephone wires. After the great cholera epidemic in 1884, the City of Naples, Italy, introduced a general scheme of sewerage. Although Rome had the ancient cloaca maxima, which still performed its functions as a drain, modern sewers were not introduced until the year 1871.

In London, the old lines of sewers discharged directly into the Thames at low-water level. Many serious evils resulted, owing to the sewers being tide-locked, deposits occurred in them and the basements of buildings were flooded. The sewage emptied into the river was carried up-stream with the rising tide and oscillated to and fro, causing the river to become extremely polluted and offensive. It was in the years 1850–1875 that Sir Joseph Bazalgette carried out the main sewerage scheme of London, consisting of a series of high and low-level intercepting sewers, which conveyed the sewage partly by gravitation, partly by pumping, to a distance of 14 miles below London Bridge. On the northern and southern banks of the river two sewage reservoirs were located to hold back the sewage, and from these it was discharged through the two out-falls during only a brief period of time after high water. But even this did not mitigate the evil of the growing pollution of the lower Thames, and a chemical treatment of the sewage, assisted quite recently by bacterial treatment, was carried out with favorable results. The annual cost of the chemical treatment

and the removal of the resulting sludge to the ocean alone costs London about $750 000 annually.

In the United States the majority of city sewerage systems were introduced after the year 1850. In 1857 Mr. James P. Kirkwood, then water-works engineer, appointed Mr. Julius W. Adams to prepare plans for the sewerage of Brooklyn. Mr. E. S. Chesbrough planned and designed the sewerage of Chicago, his first report being issued in 1858*, and Mr. J. Herbert Shedd laid down the guiding principles for the sewerage of Providence, R. I., in his report for 1874,† while Mr. Samuel M. Gray designed a scheme for the ultimate disposal of the sewage of that city in 1884.‡ Within the past fifteen years our best sewerage engineers have been kept engaged in preparing or carrying out many plans of sewer systems. In many cases, the American engineers were in consultation with European engineers, like Thomas Hawskley, William Haywood, Sir Robert Rawlinson, W. H. Lindley, Wiebe, and others, or else, like Colonel Waring, Rudolph Hering, E. Kuichling, Samuel M. Gray, and others, derived benefit from personal visits and inspections of recent European sewerage systems.

The main sewerage of Boston was planned in 1876–77,§ and executed in the following years by Joseph P. Davis and Eliot C. Clarke, and a larger scheme for the drainage of the metropolitan district, including outlying towns, is now being carried out. I confine myself to the mention of some of the older plans and reports on sewerage, and must assume that many of you are familiar with more recent plans and reports.

Where we are informed that no less an engineering authority than Sir Benjamin Baker declared in a report in 1891 that "the existing mass of literature on sewerage and sewage disposal was of quite unmanageable bulk," you will understand how impossible it is to give even a general outline of the subject.

Quite an impetus to sewer construction in this country was given shortly after the late Colonel Waring constructed in 1880, following the yellow fever epidemic of 1878, a small pipe sewer system for the

* See Report of the results of examinations made in relation to Sewerage in several European cities, in the winter of 1856–57, Chicago, 1858.

† See J. Herbert Shedd's Report on the Sewerage of the City of Providence, R. I., 1874.

‡ See "Proposed Plan for a Sewerage System and for the Disposal of the Sewage of the City of Providence," by Samuel M. Gray, City Engineer, Providence, 1884.

§ See Report by a commission, consisting of E. S. Chesbrough, Moses Lane and Chas. F. Folson, M. D., 1876, and Report on Sewerage by Jos. P. Davis and Eliot C. Clarke, 1877.

city of Memphis, Tenn., which resulted in making this town healthful and stamping out, possibly forever, the fever. The introduction of the separate system of sewerage, so ably advocated by Colonel Waring,* created quite a spirited discussion in engineering circles, and, owing probably to the fact that Colonel Waring had taken out a patent on certain details of the system, the debate was not always free from personal features. The fact, however, remains undisputed that a very large number of smaller cities, towns and even villages, took advantage of the lower cost of a system of sanitary sewers advocated by Waring to introduce a sewerage system, and thus were enabled to derive the sanitary benefits from the measure, which they probably could or would not have done had not the experience of Memphis proven conclusively the feasibility of the scheme.

The name of the late Colonel Waring and that of the Memphis sewer system are closely associated together, and perhaps I may be permitted to pause here for a moment to pay a tribute to the memory of Colonel George E. Waring. To my mind, no other American engineer has done more for the cause of public sanitation in this country than he. Having been for several years his principal assistant, I have had unusual opportunities to become acquainted with his life work, as well as with his personality. Like others, I could not at all times agree with his conclusions, but his noble enthusiasm for sanitation, his keen knowledge of the subject, his untiring efforts towards the attainment of better sanitary conditions in our dwellings, in our streets, in our towns and cities, and last, though not least, his able literary style, have always commanded my highest admiration. His masterful organization, his honest and efficient administration of the street cleaning department of our metropolis, and the creditable results attained are matters of so recent event that I need not dwell upon them further than to express the sincere hope that the time may soon come when the reforms begun by him may be again carried out in the spirit which he imbued in the cause. And as his whole life work was devoted to public sanitation, so his pathetic and almost sudden death on October 29th, 1898, from a fever, which he had done so much to eliminate, occurred in the midst of his studies of the problem how to design measures to make Cuba healthful, and to prevent for the future any danger to

* See Geo. E. Waring, Jr., Sewering and Draining of Cities, 1879, and Sewerage of Village-Cities, 1879.

health to our shores from this neighboring island. Colonel Waring rendered to his country the same invaluable services which men like Sir Edwin Chadwick and Sir Robert Rawlinson gave to England. Those of us who remain to carry on, wherever it may be required, the good work commenced by him, should never lose sight of the fact that he was the pioneer of sanitary engineering in this country.

Passing now on to the question of pollution of rivers by sewage, we find this to be another sanitary problem, which has only arisen during the past fifty years. From the earliest times it had become the custom, in the United States as well as in Europe, to consider the water-courses flowing through, or adjacent to, towns as the natural receptacles for liquid and solid refuse. When town sewers were first constructed, their principal lines were accordingly laid out on the shortest available course to the river. This unsanitary practice soon led to the pollution of the water-courses, and with increasing population the resulting evil became of such magnitude as to call for urgent relief measures. While it was contended at first that rivers and streams possessed the power of self-purification, it soon became a matter of observation that the purification thus obtained was quite insufficient in the case of the majority of streams. This problem was thoroughly studied in England, where a Royal Rivers Pollution Commission was appointed in 1868. The results of the labors of the commission were given in several voluminous reports, and in 1876 a Rivers Pollution Act was passed in Great Britain which made it illegal to discharge crude sewage into any water course, and entrusted Government Boards, like the Thames Conservancy Board, with the duty of preserving the purity of streams. France appointed a similar commission in 1874 to investigate the growing pollution of the River Seine. In Germany, an Imperial Health Board has more recently issued very stringent laws excluding crude city sewage from rivers and streams.

In the United States the same question came up first in the State of Massachusetts, where rivers have for some time been grossly polluted with city sewage and manufacturing wastes. The investigations of the Massachusetts State Board of Health, and of the Rivers Pollution Committee of the American Public Health Association, which are not yet concluded, give promise of a satisfactory solution of this troublesome problem. Our present knowledge of the matter may be

summed up as follows: Sewage discharged into a river will sometimes become purified by dilution, by oxidation, by subsidence and also by the aid of aquatic plants, of small animalculæ and of some fishes, where it is in a fresh condition when discharged. To secure a sufficient dilution, there must be a certain proportion between the average volume of dry weather flow of the stream and the maximum volume of sewage; to secure oxidation there must be a certain minimum limit of current. The degree of permissible pollution depends chiefly upon whether the water course is to be used by populations further down stream as a source of water supply. The problem becomes still more complicated when the discharge takes place into a tidal river.

As a result of the enactment of laws against river pollution, the question of sewage purification has during the last twenty-five years forged to the front. At first the problem was taken up from the point of view of sewage utilization, either in an agricultural way, by land irrigation and application of town sewage to vegetation, or else by subjecting the sewage to various chemical treatments intended to convert it into a solid manure. Many costly experiments in chemical precipitation were made, numerous patents taken out and companies formed in the expectation of realizing handsome profits from the sale of the product of chemical treatment. The lesson derived from the many instances of failures is that sewage treatment will not yield any financial profit, and that the expenditures required for purification works must be considered as necessary and legitimate in the interest of the health of a community.

Many large cities like London, New York, Boston and others seek solution of the question by a discharge of their sewage into the sea. The City of Chicago is constructing, at a cost of many millions of dollars, a drainage canal to get rid of its sewage, and to preserve the purity of its water supply derived from Lake Michigan. A similar gigantic drainage scheme was proposed for Manchester, England, by which the sewage was to be carried a distance of 15½ miles, partly through an underground conduit, to enter into an estuary of the River Mersey. Other cities like Paris, Dantzig and Berlin, and a great many small towns in England, have, since 1870, established sewage farms where sewage is purified by irrigation on land. It is

of historical interest, in this connection to note that Bunzlau, a small town in the eastern part of Germany, offers the first example of sewage irrigation, dating as far back as 1531, and in Scotland, sewage irrigation has been practiced on the Craigentinny meadows, near Edinburgh, since the year 1750. Many towns in Europe and a few in the United States purify their sewage by a process of filtration similar to that adopted for water purification, but differing from it in that the filtration is carried on intermittently instead of continuously.

Our knowledge of the subject of sewage purification, by filtration through natural soil or through artificial filter beds, has been greatly advanced by the results of studies, made under the direction of the Massachusetts State Board of Health at the Lawrence experimental station, which was established in 1888. In this department of sanitary engineering, great progress has been made since the recent researches of biologists have increased our knowledge of the functions of the bacteria. We now know that the sewage purification by filtration through land is not merely a chemical or mechanical process but principally a biological one, and that the action of bacteria is required to break up the putrefying organic matter into harmless elements, which in turn become food for plant life. Valuable experiments confirming these observations were carried out on one of the London outfall sewers in 1895 by W. J. Dibdin. The most recent experiments in sewage treatment, as carried out on a moderate scale at Exeter and Sutton in England, which were described in a paper read before this Club a year ago by Mr. Albert S. Crane, are being watched with considerable interest, chiefly owing to the fact that both processes, although diametrically opposed to each other, appear to give encouraging results regarding the solution of the sludge problem. In the septic tank air and light are carefully excluded, whereas in the coarse bacterial or contact filter beds air is very freely admitted; yet by both processes the production of sewage sludge appears to be avoided. As to the value of either method professional opinions are not by any means unanimous. Quite recently a bacterial process, based upon the theories of Dibdin, has been tried at Gross-Lichterfelde near Berlin, by Schweder, with a part of the sewage from the City of Berlin. The report of a commission of experts, who investigated the process, expresses doubts as to the successful application

of the system, and as to its economy in first cost when carried out for the purification of sewage from larger cities. Therefore, while much progress has been made in the scientific treatment of sewage, the ultimate solution, owing to the difficulties involved in the problem, must be left to the scientific minds of the coming century.

The removal and disposal of solid refuse and garbage form part of a well-arranged sanitary system of a city. Until recently, removal of garbage was usually accomplished by contract, and its disposal, in the case of cities located on a stream or at the seashore, was accomplished by discharging the refuse into the water-course, or by carrying it far out to sea. Both methods have in many cases proved to be objectionable.

It is scarcely more than ten years since it began to be recognized that the problem is one intimately connected with town sanitation, that it belongs to the province of the municipal engineer, and that it is one of the most important problems with which municipalities have to deal. Many cities of Europe have distinguished themselves by systematic efforts directed by engineers, and more recently our American engineers are paying considerable attention to the subject. Its solution is now sought for in two methods, namely, first, by the cremation of the garbage in furnaces or destructors, and, second, by its reduction by steam heat, whereby marketable products, such as grease and powdered manures are obtained, the sale of which is expected partly to cover the larger cost of the process. Garbage cremating furnaces were introduced in England about the year 1880, and in this country about 1885, since which time dates the increased attention paid to the problem. In both processes the generation of offensive odors must be avoided, and much mechanical skill has been brought to bear upon the construction of furnaces which would consume the garbage without creating a nuisance to the neighborhood. Experiments in this direction were undertaken first by inland American cities, for which no other method of disposal seemed available, as the spreading of city garbage on fields in the country was found to be objectionable. It seems a matter of regret that the late Colonel Waring, in his position of street cleaning commissioner of New York, was not allowed to continue in office, to complete the work so well begun, for he had just commenced to introduce plans concerning city

garbage, and no one appeared better qualified than he was to find a solution of the problem, which would be at once practical, economical and sanitary.

The paving of city streets and the maintenance of cleanliness on the same is another problem of municipal sanitation which has an important bearing upon the health of a city. We may note in this connection that in the last twenty years many cities of Europe and of this country have made vast progress by laying a large number of pavements with durable foundations and with water-tight surfaces. The sanitary and other requirements of city pavements have formed the subject of two important and highly interesting papers, read before this club by Mr. Geo. W. Tillson, and by Mr. N. P. Lewis, both of whom went so fully into the details of the entire question as to make it unnecessary for me to make more than this passing reference to the subject.

A few words regarding street cleaning may, however, not be amiss, particularly because it is only within a very few years that this problem has been considered worthy of being placed into the hands of engineers. The capitals and larger cities of Europe have for years distinguished themselves by efforts to maintain their principal traffic thoroughfares in a sanitary condition, and the reduction in the annual death rate of many European cities has, without doubt, been effected partly by the well-organized efforts to clean the streets, the gutters and the sewer catch basins. Leaving aside a few isolated instances of good work accomplished in the United States in this direction, I am within the limits of truth when I state that Colonel Waring's well-known recent efforts in this cause set a standard which many of the smaller cities are now following. Some improvement in the condition of city streets has already been effected by the substitution on street car lines of electric motive power in place of horses, and a further reduction in the amount of street dirt and dust may doubtless be looked for in the near future with the more general introduction of automobile vehicles.

I believe that the beginning of the new century will be distinguished by many important reforms in street cleaning. Whether such work be undertaken by contract, or be carried out by the municipal government, vigilant engineering superintendence is required.

Judging from the poor results of the system of street cleaning by contract, as now exhibited in Brooklyn, and comparing same with the splendid achievements of the New York system under Colonel Waring, one is forced to the conclusion that street cleaning should not, at least in American cities, be given out to contractors. Be this as it may, however, one of the lessons which we have learned, and which may with advantage be applied to other branches of municipal engineering and sanitary work is that no work, upon which the health and welfare of a city is depending, should be in any way associated with politics, or be directed by politicians.

Another municipal sanitary problem, which I must briefly review, relates to the provision of healthful food supplies, and a proper and efficient food inspection. In the beginning of our century open markets were replaced by large covered structures. This innovation was inaugurated in Paris by Napoleon the first. In 1811 the planning of the now famous Halles Centrales was commenced, but they were only completed in 1878. In the past thirty years many of the larger cities of Europe and a few in the United States have erected imposing architectural structures in which the sale of food provisions takes place. Their chief advantages are the protection which they offer to the market people and to the public against the weather; the fact that the provisions are not damaged by rain, snow, heat, cold or street dust; that fresh market products are obtainable daily, and that the control of the food supply is facilitated. Market houses require well-arranged traffic connections with the railroads, rivers, canals, harbor docks, and good roads to the country districts, and thus offer sanitary, architectural and engineering problems. In recent years much attention has also been devoted, particularly in England, to the sanitation of bakeries, which have been brought under the supervision of the health boards.

Intimately connected with the public markets are the slaughter houses or municipal abattoirs, which do away with the nuisance of private slaughtering, and facilitate the important inspection of the meat. In Europe municipal abattoirs were inaugurated first by the great Napoleon, who by his decree of 1810 prohibited all private slaughtering and thus did away with a formidable sanitary evil of cities. Since the middle of this century nearly all large European and

many American cities have built centralized abattoirs located remote from the crowded city districts. Many architectural and engineering questions are involved in the planning and construction of such structures. Their sanitary and mechanical equipment, the provisions for water supply, ventilation, purification of the waste water and blood, the installation of cold storage plants, hoisting machinery and other labor-saving devices, the paving and drainage of roadways and yards, and the provision of suitable rail and water connections must be judiciously considered. The trades connected incidentally with the slaughtering of animals, such as rendering, fat-melting and bone-boiling establishments, are now likewise brought under sanitary control. The most modern abattoirs are also fitted up with complete bacteriological laboratories for the microscopical inspection of diseased or suspected meat. With the system formerly in vogue of having small slaughtering establishments scattered over a city, no efficient inspection was possible. In the last twenty-five years American cities have profited much in this branch of municipal sanitary administration by the experience of the older cities of Europe.

Since 1850 another very important municipal problem has arisen in many of the older towns of Europe. I refer to the enlargement of the cities and the partial reconstruction of their system of streets and thoroughfares. The progress of modern industries, the extension of commerce, the movements of populations from the rural districts into the cities, and the doing away with many of the old fortifications and walls, which protected but also hemmed in the cities and prevented their growth, have created new and important municipal problems. Since 1850 many cities and towns of Europe have undertaken magnificent and comprehensive works for the transformation of their street traffic, for the building up of new urban districts, for the laying out of parks and squares. The instance of Paris, under the era of Baron Haussman, is probably familiar to you. In the period from 1852 to 1871 many new boulevards and grand avenues of communication were laid out with roads of shade trees, parkways and garden strips, while Mr. Belgrand, the distinguished engineer of Paris, planned and executed its now famous underground works. In Vienna the old fortifications were destroyed after the year 1857, and the famous Ring-Strasse, or belt street, a magnificent boulevard lined with costly

palaces, museums, theaters and other public buildings, became the principal feature of the city improvement plan.

In Germany the recent transfiguration of many of the historical and mediæval towns has been even more remarkable. The old narrow and crooked streets with dark dwellings and warehouses have disappeared, and given way to widened and straightened avenues, with modern residences or stores; new suburbs have been laid out with engineering skill and provided with water and sewerage facilities; towns situated on the banks of rivers have had their water frontages improved for commercial purposes or for the embellishment of the city, and wherever one goes one finds municipal sanitary improvements, such as sewer systems, works for the purification of both water and sewage, city hospitals, magnificent public schools, market buildings, cattle markets and abattoirs.*

In our own country the next fifty years will doubtless see a large amount of similar work done, and if the past has not been distinguished by works for the enlargement and embellishment of cities, this is entirely due to the fact that with very few exceptions all our cities are comparatively young and in the process of development. In this connection I am glad to notice that this subject has recently been taken up by the Architectural League of New York, a progressive body of architects. In three special public meetings they proposed discussing the following subjects, viz., the reconstruction of the city's plan, below and above Fifty-ninth Street, and the water fronts of the city, plans for bridge approaches, driveways, subways, docks, etc. In Brooklyn the Department of Architecture of the Institute of Arts and Sciences has now a movement on foot for interesting the general public in such broad questions as the public aspect of our cities, the location and arrangement of our parks and gardens, the adornment of our streets and squares, the better housing of the people, town sanitation, etc.

In those few American cities which are more than one hundred years old the question of providing decent and sanitary homes for the poorer population in crowded city districts has arisen, just as it did in Europe. In England interest in this problem was first aroused by the report of Sir Edwin Chadwick on the condition of the laboring

*See Chapter on "The Laying Out of Cities and Towns" in Wm. Paul Gerhard, *Sanitary Engineering*, 1898.

population, published in 1842. In 1856 the first committee was appointed by the State of New York to inquire into the condition of the tenements, and its report was issued in March, 1857. The tenement house question has ever since remained one of the municipal problems of large cities. About twenty-five years ago the well-known Peabody workingmen's buildings were erected in London, likewise the improved industrial dwellings of Sir Sidney Waterloo. On a large scale, the problem was successfully solved in Brooklyn, in 1877, by Mr. Alfred T. White, the esteemed honorary member of our Club, who erected the Riverside apartments and other model tenements.

In New York the Improved Dwellings Association, the Tenement House Building Company, and other similar organizations of more recent date attempted the solution. The City of New York proper offers, largely owing to the unfortunate and arbitrary limit of the ordinary city lot, the best example for the study of the evil effects of the tenement-house system. From time to time citizens' associations and Legislative Tenement-House Commissions have devoted study to the inspection and to suggestions for the improvement of tenement houses. In this connection the Model-Tenement-House Competition, organized in 1878, by the *Sanitary Engineer*, now *The Engineering Record*, a journal for municipal engineering, under co-operation of several public-spirited citizens, deserves special mention. Many of the plans submitted by architects in this competition showed great improvements, but still the conclusion of the competition committee was that it was impossible to secure sanitary results in the erection of a tenement on a narrow lot. The progress of recent years is due to the passing of the Tenement-House Act, in May, 1879, which limited the space of the lot to be built upon, required all bedrooms to have windows for direct admission of light and air, and gave to the board of health increased powers to regulate the question. A vast improvement in the character of the plans for tenement houses submitted to the city departments has been noticeable since this act became law, and further progress followed the labors of the Tenement-House Commission of 1894.

The last fifty years have witnessed such vast improvements in the construction and sanitary features of dwelling houses that it seems

impossible, in the limited time at my disposal, to even give a general outline. One important result of the efforts in the interest of sanitation is that the details of drainage, ventilation, water supply, lighting and general sanitation, and the installation of sanitary appliances are now in many cases entrusted to sanitary engineers who make a specialty of domestic engineering. The field of their practice is a large one, and the progress made in the past fifty years has been far-reaching. As an example of what has been accomplished in our era of sanitation, I will mention that, while water-closets were invented hundred years ago, all really sanitary types were introduced within the last twenty-five years. At the middle of our century the much-condemned pan-closet was universal. Prior to the year 1850 there was not a house fitted with plumbing conveniences which had any kind of vent pipe carried up to the roof for ventilation. At the close of our century the fundamental principles of house drainage and sanitation are well and firmly established, and in nearly all cities and towns the installation of plumbing is regulated by health or building department rules and regulations, and the work is inspected by more or less skilled inspectors.

The benefits due to sanitation have not been confined to our dwellings, but marked improvements in the planning, construction and equipment of hospitals, schools, prisons and military barracks are noticeable in all civilized communities. New domestic engineering problems have sprung up with the advent of the modern tall office buildings. In hospital construction the old block plan with crowded and insufficiently ventilated wards has been superseded by the pavilion system, for sanitarians are agreed that it is better to extend buildings for the care of the sick over large areas rather than to pile up story over story. Even the large cities of Europe locate their new hospitals in the suburban districts and plan a large number of one or two-story detached wards, sometimes connected by covered corridors, and thus secure plenty of light, air, avoidance of dirt, and maintenance of fastidious cleanliness. In New York and a few other American cities of metropolitan character the high price of land in all sections of the city compels adherence to the old system, and there is, perhaps, still a tendency to give too much attention to purely ornamental features. The State care of the insane offers another

example of the improvement in sanitary administration for mentally sick patients, which is a result of the last ten years of the nineteenth century.

A vast improvement is also noticeable in the construction and equipment of public school houses, it being recognized that healthy minds can only be formed in healthy bodies. Much attention has accordingly been given to the problems of heating and ventilating the class-rooms, of providing decent and inoffensive sanitary conveniences, and of encouraging personal cleanliness of the pupils by establishing free school baths, but I can only make a passing reference to this branch of municipal improvement.

Our prisons and jails have also been vastly improved, and prison sanitation has been the outcome of modern sanitary science. Formerly dark and unventilated cellars of court houses, towers in castles and underground cells in convents and monasteries were used for the confinement of prisoners. Epidemics of typhus fever or other contagious and infectious diseases were common, and often threatened even the health of judges, jurors and court officers. In the improved modern structures the influence of imprisonment on the health and the nervous system of the convicts has been reduced to a minimum.

The States of Europe, which compel their citizens to perform military duty, have become conscious of the moral obligation resting on them of providing healthful military habitations, and the modern military barracks differ as much from the older barracks erected in fortified towns centuries ago, as do the private dwelling houses of our period from those of the citizens during the Middle Ages.

The erection within the past twenty or thirty years of an annually increasing number of public bathhouses in cities and towns, both in Europe and recently in the United States, forms another illustration of the fact that all large sanitary municipal improvements date from the year 1850. Before this date, the practice of bathing was not a general one, and was entirely confined to river and sea baths available only during a few months in the year. England set in 1842 the example for municipalities in providing public baths for the people, and since 1850 the principal cities of the continent, particularly in Germany, have imitated it. In the United States much interest has been awakened in this subject, and the State of New York was the

first to pass an act (in 1893) making the erection of free public baths open the year round mandatory upon all cities of 50 000 or more inhabitants. Without going into details, I will mention that for the attainment of bodily cleanliness the rain or spray bath is much superior to the swimming bath, though I do not wish to be understood as underestimating the improvement of the general bodily health due to athletic exercise in the swimming bath.

In my judgment it is just as necessary that a municipality should provide public baths as it is that they provide public schools, well-paved and clean streets, sewers and fire and police protection. A valuable and highly interesting report on public baths was rendered in January, 1897, by the Mayor's committee, of New York. Several smaller people's rainbaths are already in use in New York, and larger bathing establishments are soon to be erected. Buffalo, Boston, Chicago, Philadelphia, Pittsburgh and other cities have within the past ten years erected such baths; even the smaller cities make progress in this direction, and I cannot help remarking that notwithstanding the mandatory character of the public bath act, passed by the New York Legislature, our own city of Brooklyn has made no attempt whatever to further bodily cleanliness by providing cheap or free baths for the people.

Much work of a sanitary character has been accomplished in the past years in rendering malarial districts healthful. As an instance I will mention the Roman Campagna, which, according to the investigations of Professor Tommasi-Crudelli, became malarious because the old Roman drainage works became stopped up. A part of this beautiful tract of land has again been made healthful by re-establishing the former efficient drainage of the subsoil, which renders its pores free from excess of water, and thereby permits air to enter them to oxidize the impurities. In our own country there are vast tracts of land which now form swamps and which could be reclaimed by a similar process.

In the past twenty-five years many other important questions have come up which I have only time to scan very briefly. Among these I mention the question of smoke prevention in cities. Smoke and city fog are in many ways injurious to health; the atmosphere of cities is

defiled by the carbonic oxide and the sulphuric acid; the smoke becomes hurtful to persons with delicate lungs; it likewise interferes with the free ventilation of the dwelling-houses, and it causes buildings and sculptural monuments to be disfigured. The difficulties involved in the question of smoke abatement were recognized, even in the last century, and Benjamin Franklin, James Watt and Count Rumford studied the problem. Some of the remedies thus far suggested are the use of hard coal, the application of smoke-consuming appliances to the boilers, the use of gaseous fuel for cooking, heating and for small motors; the better firing of boilers, and, lastly, the removal, as far as possible, of large manufacturing industries to the suburbs, or at least away from the crowded city districts.

General town sanitation includes also, according to Olmsted, the provision for and the laying out of public parks, boulevards, open squares and playgrounds for the population. It is now well recognized that one acre of trees, grass and shrubbery in the heart of a city is of far more sanitary advantage to the town dweller than hundreds of acres outside of the city limits, which are not easy of reach. Within the city blocks much improvement may be effected by changing the rear of building lots into gardens having low dividing fences or better still no fences at all. A recent sanitary improvement of the cities of New York and Brooklyn, which is worthy of mention, is the establishment of recreation piers at the river fronts. It is to be hoped that this will be followed by efforts to improve the water fronts and the condition of public water-courses.

The sanitation of public washhouses and steam laundries, the establishment of disinfecting stations, and the sanitary questions involved in the disposal of the dead in large cities, are other sanitary problems attracting attention at present, but they belong more to preventive medicine than to engineering.

The work done in the last thirty years by state boards of health has been important and far reaching. In the year 1849 the Massachusetts Legislature passed an act appointing three commissioners to prepare for a sanitary survey of the State. Their report, largely gotten up by Mr. Lemuel Shattuck, a public-spirited citizen of Massachusetts, called attention to the awakening of sanitation in England,

but was received with general apathy. Twenty years later, in 1869, the first State board of health was established in Massachusetts, and Dr. H. I. Bowditch was made its first president. The first report of this board was issued in 1870, and ever since its annual publications have been eagerly sought by sanitarians and sanitary engineers. In Michigan a State board of health was created in 1873, in New York State in May, 1880. At this time but very few of the States of the Union are without such a useful institution. Much matter of permanent value to sanitary engineers is found in the annual reports of these boards of health. I have already mentioned the valuable results achieved by the Lawrence experimental station established in Massachusetts, and in October, 1886, a State laboratory of hygiene was established by the Michigan State board of health.

In 1866 a city board of health was created in New York City, and to-day nearly every city or town has its board of health, whose labors are devoted to the cause of town sanitation. A valuable feature of these labors consists in the preparation and publication of vital statistics and of sanitary maps, profiles and diagrams, exhibiting the relation between location of old water courses and the mortality in various city districts; of the relation which sewerage, density of population, meteorological conditions, etc., bear upon mortality; of the influence which the height of the ground-water has upon mortality, etc. Valuable results have also been accomplished by sanitary commissions, such as the one appointed in England in 1855 during the war in the Crimea, and in our own country, the United States Sanitary Commission of 1861. In many cities of England, and in a few of those in the United States, sanitary protective, inspection or assurance associations were formed for the annual inspection of dwelling houses, and much good has come from their labors.

The recent introduction of sanitary science at the universities, and of special courses in sanitary engineering at the technical colleges, both in Germany and in the United States, is another step in the direction of sanitation. A great deal of good has likewise been accomplished by the scientific and literary press, which is laboring indefatigably to establish and spread the knowledge of sanitary principles among both professional and lay men.

Our cities and towns are framing building laws and sanitary ordin-

ances, regulating not only safe construction and protection from fire, but also healthful building construction and healthful modes of living. The width of the streets, the height of the houses, the size and height of rooms, the position and number of windows, the details of heating and ventilation, of plumbing and sewerage, of prevention of dampness, surface drainage, avoidance of defective gas piping and others are now regulated by law.

In all engineering works the results attained by the expenditure of large sums are of immediate interest to the public. Statistics gathered in different countries give proof of the marked beneficial effects upon the public health of municipal sanitary measures, such as sewerage, water supply, drainage, street cleaning, etc. Some epidemics, which in former times appeared periodically are now practically extinguished in certain sections of the country, and banished entirely from many cities. The decreased death rates of cities, as shown by annual statistics, form the best evidence of the good influence of sanitary works.

Take, for example, the case of London, at different periods of history the death rates were as follows:

From 1660–1679, the annual death rate was 80 per 1 000; from 1681–1690, 43; from 1746–1755, 35.5; from 1846–1855, 24.9, and in 1871 it had come down to 22.6 per 1 000.

In Croydon, near London, the rate was as follows: From 1848–1855, 24.03 per 1 000; 1855–1875, 19.56, and from 1876–1880, it was 17.07 per 1 000.

In Brussels the death rate was: 25.00 per 1 000 in 1875, and 18.1 per 1 000 in 1894.

In Vienna the death rate was: From 1848-57, 42.0 per 1 000; 1878–88, 28.6; 1893, 24.3, and in 1894 it was 22.8 per 1 000.

In Buda Pesth the figures are as follows: In 1876, 41.0 per 1 000; in 1892, 27.9, and in 1895, 24.4 per 1 000.

In Milan, Italy, the rate was 30.00 per 1 000 before 1880, and was reduced to 21.00 per 1 000 in 1894.

In Copenhagen the rate was 24.00 per 1 000 in 1884, and 18.7 per 1 000 in 1894.

In Stockholm, Sweden, the figures were: In 1877, 28.7 per 1 000; in 1884, 24.6, and in 1894, 18.3 per 1 000.

German cities present even more striking examples of the benefits derived from sanitation. In Hamburg, for instance, in the period from 1838–44, before the sewerage system was introduced, the rate was 48.5 per 1 000. In the period from 1845–1853, during the construction of the sewer system, the rate of mortality was 39.5. From 1854 to 1861 (the first eight years after the sewer system had been put in operation) the rate was 29.9. From 1862–1869 the rate was 22.0 per 1 000, and from 1871–1880 it was 13.3. In Dantzig the rate was as follows: From 1863–1868 (before sewerage), 38.4 per 1 000; 1869–1871 (during construction), 34.6, and from 1872–1880 (when sewer system was completed), the rate fell to 28.8 per 1 000.

Regarding deaths from typhoid fever, the following figures are instructive: The mortality in Munich from typhoid fever prior to 1859 was 24.2 per 10 000 deaths; from 1860–1865, when there was no sewerage, 16.8; from 1866 to 1873, when there was partial sewerage, 13.3, and from 1875–1880, after the sewerage system was completed, it was 8.7. In Frankfort-on-Main the typhoid mortality was 8.7 from 1854 to 1859, when there was no sewerage, and in the period from 1875–1887, after sewerage was completed, the rate of mortality fell to 2.4 per 10 000. To mention just a few examples from our own country: In St. Louis the annual death rate in 1860 per 1 000 was 32.0, and in 1865–1870 it became reduced to 20.00. The city of Memphis had formerly a death rate reaching as high as 109 per 1 000, and in the year 1897 its rate had been reduced to 23.56. These examples might be multiplied, but the figures given are sufficient to prove the good results due to sanitation and sanitary measures introduced during the past fifty years.

In conclusion, let me emphasize once more the fact that greater progress in municipal sanitation has been made in the last half-century than in all preceding centuries combined. My incomplete sketch has, I trust, served to indicate that whenever in any period of history civilization advanced, some sanitary measures were carried out, and that whenever general culture and refinement declined sanitation became neglected. Civilization and sanitation are so closely allied that one cannot exist without the other. As an evidence of this progress, advanced sanitarians seem now to be agreed that the prevention of disease is the highest aim of modern medical practice.

Concerning the prospects of sanitary reform in this country, an encouraging feature is the ever-increasing interest taken by the press and by the general public in questions which have a bearing upon the welfare and health of communities, and in which engineers are so largely involved. The twentieth century will, doubtless, witness a still further advance in all the branches of work outlined in my paper.

The work of sanitary engineers is to a large extent unostentatious and inconspicuous, much of it being underground and concealed. Their plans, suggestions and ideas are often unpopular and not looked upon with favor, because they burden the community with heavy expenses and necessitate special taxes. But I am convinced the day will come when sanitary works will be universally appreciated and when sanitary engineers will be more generally honored and esteemed. I also venture to predict that in the coming century the memory of our school children will not be taxed with dates of ancient wars and of battles in history so much as with dates from the history of civilization, of discoveries and inventions, and of the progress of civil engineering. And that will also be the day when nations will seek glory, not so much in wars, as in proudly showing the largest amount of those public engineering works which by the amelioration of sanitary conditions reduce preventable sickness and death in communities.

DISCUSSION.

Mr. Whipple. Mr. George C. Whipple.—I want to say that I have been very much interested in the paper that has been presented, and I think it a very suggestive one. I think it emphasized very strongly one fact that we cannot help having noticed, that is, that the work of sanitation is the work of the engineer. Now for a good many years, and even at the present time, the supervision of our public health is in the hands of medical men, and I think that in the coming twenty-five years we shall see a gradual transference from medical men to engineers. It seems to me that for that reason our engineers ought to broaden out in their education along the lines of chemistry and biology and, also, if our medical men are to keep in with the sanitary work they must study engineering.

A Member. A Member.—I would like to ask if the disposal of sewage has not, in some cases, been made a source of profit to the city.

Mr. Gerhard. Mr. Wm. Paul Gerhard.—So far as I know, there is not an instance on record where sewage disposal has been a source of profit.

Mr. Tillson. Mr. George W. Tillson.—Some mention was made of the public baths here in Brooklyn. I noticed within a day or two an item in the *Eagle* stating that the deputy commissioner of public buildings, lighting and supplies hoped to open some more public baths. Cannot Mr. Wynkoop tell us something about this?

Mr. Wynkoop. Mr. Hubert S. Wynkoop.—I cannot say anything definite. What Mr. Tillson says is news to me. But we should have more public baths here. We have five now, having built two within the last two years, and the old City of New York, that is, the Boroughs of Manhattan and the Bronx, has fifteen, so you can see our number is a very small proportion. I know we have been trying for some years to get more public baths, and finally did get leave to build two new ones here, larger than the old ones, and fully equal to any they have across the river. I cannot give anything definite with regard to the future policy of the department in this matter.

Mr. Gerhard. Mr. Wm. Paul Gerhard.—Did I understand Mr. Wynkoop to refer to baths along the river front?

Mr. Wynkoop. Mr. Hubert S. Wynkoop.—Yes. The baths go into service, if we have good luck, in June, and are kept open until the last of September. The free floating baths are nothing but great big tubs, with slats instead of a solid bottom. They are patronized very largely, and I would like to say in that connection, that I had my attention called to the fact that people, youngsters in particular, of both sexes, walk all the way from Manhattan Crossing to the public baths in the neighborhood of South Ferry. Along in the spring they begin to watch the newspapers to find out when the baths will re-open. Little fellows

five years old will walk all the way down whenever they can get a chance to go in swimming in the public baths. Mr. Wynkoop.

Mr. Wm. Paul Gerhard.—No doubt those baths accomplish a very good object, but the law intended something entirely different. It intended to have cheap structures erected, kept open the year round, where warm water is supplied for bathing, with soap, thereby establishing cleanliness, which cannot be done in a river bath. Four or five years ago the health commissioner of Brooklyn, Dr. Emery, interested himself in this question. He had some plans made and submitted them to the Mayor, but that was the last that was heard of them. They were doubtless pigeon-holed somewhere, and nothing has been done about them since. Mr. Gerhard.

Mr. J. Calvin Locke.—I would like to ask Mr. Gerhard if there is a single instance of garbage reduction that is really a profit. Do they get profitable materials in quantities large enough to pay for the work? Mr. Locke.

Mr. Wm. Paul Gerhard.—That is rather a difficult question to answer. I would prefer to have some gentleman reply who is connected with work of this nature. Mr. Gerhard.

Mr. George W. Tillson.—Wherever garbage is reduced now by steam, as you have outlined, is it a fact that the contractor is paid a large sum for collecting and receiving garbage and doing away with it, and anything that he may make in addition is known to himself only? Is it a fact that he does it for the compensation he receives from the city? Mr. Tillson.

Mr. Wm. Paul Gerhard.—He does it, no doubt, for the compensation which he receives from the city. It would take a great many years before he could derive a profit from his plant. Because if he puts up a plant, sanitary in every way, it will be a very expensive one. The only plant I know of of that type is down at Barren Island. I saw quite recently a report rendered by several engineers, one of them, Mr. John Bogart, about the works at Barren Island. It was stated that the smell was not noticeable at a distance greater than 500 ft. I cannot tell you where I saw this report, but it was within the last week. I think Mr. Taylor, who used to be connected with the health department, is one of the engineers who examined the plant. Mr. Gerhard.

Mr. Joseph Strachan.—I have seen advertised lately an attachment to be used in the kitchen for the consumption of the household garbage. I would like to ask Mr. Gerhard if he considers that a sanitary appliance. The arrangement, I believe, is attached to the smoke pipe of the range, and the garbage is dried sufficiently to burn in the range. Is that a strictly sanitary appliance or is it apt to be abused, during its operation, by the domestic? Mr. Strachan.

Mr. Wm. Paul Gerhard.—Undoubtedly it may be abused by domestics. I have had an arrangement put up in my own house and Mr. Gerhard.

Mr. Gerhard. I am very favorable to that device, and there is hardly any garbage to cart away. Most of it is consumed in the basket which is inserted in the smoke pipe. The garbage is thus carbonated, and can be used the next morning almost in the same way as kindling wood to make the fire. Fat should not be put with the other garbage. I once nearly had a chimney fire in my house caused by fat burning, that had been put into this basket.

Mr. Wynkoop. Mr. Hubert S. Wynkoop.—We used to burn garbage in the range until the landlord grew tired of paying for new fire brick, and then we had to dispose of it in the old fashion.

Mr. Rowell. Mr. George F. Rowell.—Mr. Gerhard spoke of those reports on Barren Island, and I would like to correct any impression which he may have conveyed with regard to that 500-foot limit. I have had occasion to study those reports recently, and I noticed that the 500-foot limit was used in connection with other plants at Barren Island. The report, as I remember it, distinctly says that the odors from the utilization plant where garbage is reduced carried for a number of miles.

Mr. Tillson. Mr. George W. Tillson.—The author, in speaking of sewerage, referred to Memphis. It happened to be my fate to go down to Memphis and do some work in connection with the sewerage system under Colonel Waring, in 1880, and the condition of things that existed there from a sanitary or civilized standpoint was something surprising.

Memphis at that time contained about 40 000 people. Of course you all know its climate, and it had practically no sewers. It had no sewer system, but there were four or five individual sewers that had been built, and were owned by private parties.

When the system which Colonel Waring planned at the time, was put in, the city bought up and made use of, to a certain extent, all those existing sewers. The city, at the same time that it put in the mains and laterals, did sometimes run up long private connections for the use of the property owners, so that they might all stand at practically the same level when they came to make a connection. In one case where I saw a connection built through a private alley about 75 ft. long, we ran through three cesspools that had been constructed nobody knew how long; but when they had become filled up, or so much so that they could be used no longer they had been simply covered over and left there with the fecal matter, and all the other refuse to decay and filter out into the soil. Now Memphis was honeycombed, at that time, with just such things all over it, and they had a water supply at that time. It was said that, while the first outbreak of the fever, in 1878 I think, did come from the lower part of the city, and among the poorer people, the outbreak in 1879 came from some of the wealthiest families, and the explanation of that was that they

had used their backyards and gardens for these cesspools. The people considered that it was an infringement upon their private rights when an attempt was made to restrict them in the use of their houses in any way. Mr. Tillson.

As the author has said, since that time there has been no outbreak of that kind, or an epidemic of any kind there. It also may be of interest to know how far a great many of the cities in the South and West go before they adopt a sewerage system. You all know that the water system must come first. As I said before, in the City of Memphis with 40 000 people, a city that had been of commercial importance for a great many years, there were practically no sewers. In 1893 or 1894, the city of Macon, Ga., a city also of 35 000 or 40 000 people, received bids for constructing sewers in the entire city. In the spring of 1895 the city of San Antonio, another southern city, where the people go for their health, received bids for constructing a sewerage system for the entire city. They had no sewers up to that time, while in the East, and further north in the West, it is almost impossible to find a village of over 5 000 inhabitants without some attempt at a sewer system. I have been surprised in visiting friends and relatives in the smaller towns of New England that I left 15 or 20 years ago, with no signs of water or sewers, to find how many, and almost all of them of 3 000 inhabitants and more have a water supply and a few sewers. This emphasizes what the author has said with regard to the rapid growth in sanitation in the last few years.

Mr. Joseph Strachan.—In speaking of the advance that has been made in cities in the United States, I think a little too much credit is given to them. There are two good-sized towns not very far from here, which are supposed to be more or less progressive in their ideas, that have no sewer systems. Those two towns are Hempstead and Jamaica, and they have been an eye-sore to Brooklyn for a good many years. The drainage from both of these towns has affected the water supply of Brooklyn, yet notwithstanding that they have not yet been sewered, although lately the town of Jamaica, taking advantage of the coming consolidation of the town with Greater New York, issued bonds and built an extensive sewer system, and I believe it is entirely constructed now—without any outlet. Mr. Strachan.

The other town, Hempstead, when the city of Brooklyn proposed to spend $150 000 to take some of the nastiness of its streets alongside of our Hempstead storage reservoir and drop it into the Bay where it would do no harm, made the objection that, though it would increase the purity of the water supply of about a million and a half people, it would damage their oysters. Those are two instances of eastern progressiveness.

Mr. Andrew J. Provost, Jr.—I am sorry for one that Mr. Gerhard cut out all those statistics so ruthlessly. They won't appear until Mr. Provost.

Mr. Provost. the next annual publication, a year from now. I would like to put a few statistics in here. An eminent English scientist, Dr. Gairdner, about 40 years ago stated that it was probable that the inevitable mortality would be about 17 in 1 000 people per year. At that time London and other English cities were running along about 50. That was during the time that the author spoke of when the sewers of London were emptied directly into the Thames. About four years after that the sewers of London were carried, as Mr. Gerhard said, 14 miles below the city, and almost immediately the death rate dropped from 1 in 20, or 50 in 1 000 per year to 1 in 45, or about 21 per 1 000 per year, and those figures have been nearly stationary ever since, according to records I have seen. They got down as low as 19 in 1 000 and then crawled up again to about 21.

New York at that time had a population of 900 000, and the death rate was 1 in 35.7. Previous to that, in 1810 and long before the Croton water had been introduced, the death rate in New York was very much lower, but it crawled up to its maximum in 1860 to 1 in 35. It was about that time that so much attention was given to this subject of death rate and to the sanitary conditions of the city.

The *City Record* during last year shows that the average for Greater New York has very closely approached the figures which were given by Dr. Gairdner in 1862. The New York death rate fluctuates between 17 and 20 per 1 000 per year, and that seems to be about what other cities, with equally good sanitary appliances, have attained.

This same authority says that previous to the establishment of good sanitary government in London, the death rate was 1 in 20, and that in 1863 it had been improved to 1 in 45. In Liverpool before the establishment of good sanitary government, 1 in 28, and this has been improved to 1 in 44. In Philadelphia the death rate has been improved from 1 in 39 to 1 in 44, clearly showing the effect of all these different methods of improvement described by the author.

I would also like to ask a question with regard to the bacteria process which was used in Germany. It was stated that the report was qualified as to its being a success, and I would like to ask if the methods used there were along the lines laid down by Dibdin and others which have apparently been successful in England.

Mr. Gerhard. Mr. Wm. Paul Gerhard.—This experiment was tried in a small place near Berlin and was made with Berlin sewage. The engineer who made it is named Schweder, and about ten days ago I received an extract from his paper, and also from the report of the commissioners and I have sent for both the paper and the report to verify the statement. As far as I can make out from this extract the engineer has imitated Cameron's suggestion of a septic tank. He has three parts in his system, at first he had four, but he has dropped one part.

First he had a sediment tank. Then he had a septic tank proper where light and air were excluded, and, after that, a coarse filter, exactly like Dibdin has suggested. Mr. Gerhard.

Mr. Andrew J. Provost, Jr.—They are very conservative in England. There the local government boards have been very slow to adopt this method of Mr. Dibdin, and also that of the septic tank. During the past year, however, it seems that this conservatism has given way somewhat, as the process is now in operation in many cities and towns in England where they have before been very strict. Last year at a meeting of the Health Association of London a prominent scientist made a statement something like this: He said that the year 1897 would ever be memorable for the prominence given during it to the subject of bacteriology in sewerage, and the process seems to be in successful use wherever it is tried. Mr. Dibdin has succeeded during the past year in improving his system by the cultivation of the bacteria. At the time Mr. Crane's paper was read before this Club, a year ago, that had not been established. Mr. Provost.

Mr. Wm. Paul Gerhard.—Mr. Provost is quite right in stating that Dibdin's method is attracting a great deal of attention in England. I do not know whether it has been approved yet officially, as I understand that there is a Royal Commission now investigating sewage disposal, but their report will probably not be ready for a year or so. I also want to mention that the large city of Manchester, up to within three or four years ago, could not find any way out of the sewage difficulty whatever, except to carry the sewage to the sea through the River Mersey by building a drainage canal, similar in magnitude to the Chicago Drainage Canal. They have now engaged Mr. Baldwin Latham, and he is at present favoring Mr. Dibdin's scheme, so that in England it does seem as if many consider that as a solution of the problem. Mr. Gerhard.

Mr. Andrew J. Provost, Jr.—I noticed in Mr. Crane's paper the statement that Mr. Baldwin Latham was opposed to the Dibdin system, but it seems that he has been converted. Several other engineers have also changed their minds. The action of the local boards in England, as I understand it, has been for the last five years to allow chemical precipitation to be used, provided sufficient land was also obtained to purify the effluent by broad irrigation. But recently they have made an exception and allowed towns to use the bacteriological methods without the purchase of sufficient lands for broad irrigation, on condition that the towns themselves would be responsible for the result. The process has not been permanently approved, and is not likely to be, before this Royal Society, which is now holding its session, as stated by the author, reports the results of its investigations. Mr. Provost.

Mr. J. C. Meem.—One subject suggested itself to my mind. That is, the question of tearing up public streets for putting down connec- Mr. Meem.

Mr. Meem. tions and mains. I think that there are a good many cities in the United States that have alleyways in the blocks, and that a good many of these alleyways are used for carrying off garbage and things of that kind. Wouldn't it be a good idea to use these alleys also for putting in lateral pipes, all kinds of supply pipes and sewer pipes, and put only mains in the streets? Wherever suburbs are laid out make it compulsory that alleyways should be provided in all blocks, and the same thing in all new towns.

Mr. Gerhard. Mr. Wm. Paul Gerhard.—I think Mr. Meem's plan would be practicable as far as sewers are concerned, and I know that in St. Louis all district sewers are laid in the alleys. As far as water mains are concerned I don't know.

Mr. Meem. Mr. J. C. Meem.—Couldn't supply pipes be put in as well, running laterals, sufficient for the houses, along the sidewalk? I should think that would be practicable.

Mr. George W. Tillson.—Memphis had alleys running both ways.

BROOKLYN ENGINEERS' CLUB.*

No. 17.

ELECTROLYSIS: AN UNSOLVED MUNICIPAL PROBLEM.

By Hubert S. Wynkoop, M. B. E. C.

Presented March 9th, 1899.

When, in 1887, after many years of desultory experimenting, both in laboratory and on track, the electric street railway became a commercial practicability, it was welcomed by all as the ideal of municipal transportation, the savior of city pavements, and the conservor of public health. Naturally, so radical an innovation was bound to receive its full share of criticism; but the objections that were brought forward at first gradually died away. The æsthetically inclined were forced to admit the utilitarian advantages of overhead wires; the city fathers abandoned the promulgation of amateur schedules and impracticable regulations; while even the countryman, driving homeward a span of horses wrung from the railway company in recompense for his electrocuted mule, sang the praises of the new style of locomotion.

Thus, all objections seemed to be met; but there lay in embryo, even at the very beginning, a condition inseparable from the single overhead trolley, a condition destined to be born several years later and christened electrolysis.

In order to discuss this problem properly, it is desirable to antedate the electric railway a few years, and glance at the relation of electrical interests to the public highways and to each other. The

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telegraph, first in the field, had secured lodgment on the highways, either by mere consent of the property owners or by due authority of law. The telephone, being similar to the telegraph in so far as both required the erection of overhead wires, promptly occupied the highways under the precedent furnished by the telegraph. Now, both telegraph and telephone employed a ground return, the current traveling along a wire from the sending to the receiving point, passing thence to the earth and returning to the sending point by means of pipes, metallic veins and water courses, The use of the earth as one side of an electric circuit seemed perfectly legitimate thus far.

In 1880 the arc light appeared. No attempt was made to take advantage of the ground as a conductor; yet, as a matter of fact, the leakage from the arc light lines crept down the poles and ran riot underground, seeking a fitting pathway back to its source at the dynamo. Telephone receivers buzzed, drops fell and signal bells rang false alarms. Then arose the first murmur, that was ultimately to end in a vociferous demand on the part of the telephone for the exclusive right to use the earth as a return conductor. However, in one way or another, the telephone succeeded in effecting such arrangements as remedied the evils due to its own sensitiveness.

Next came the incandescent light, direct and alternating. The telephone suffered more severely than before; but, as the latter trouble was merely an exaggerated counterpart of that caused by the arc light, the same remedies proved effectual.

It must not be understood that the telephone won without invoking the aid of the courts. In an address before the New York State Bar Association, John S. Wise said:

"A great deal of litigation ensued between the light companies and the telephone. There was no doubt that either the one or the other of these companies could prevent these disturbances. The telephone had it in its power, by putting up a complete metallic circuit to relieve itself of troubles, both from induction and earth leakage. * * * But the system of grounded circuits was much cheaper for the telephone, and it was not disposed to yield that economical method to the electric light companies, especially as the electric light companies could also use parallel return wires, remove their wires to some distance from the telephone, were the last comers, and had no better title on the highways than had the telephone itself. Many cases between the telephone and electric companies were tried. In the majority of cases the light companies were compelled to remove their wires to a sufficient dis-

tance from the telephone, or to introduce parallel return wires to avoid inductive disturbances to their neighbor. On the whole, the telephone companies were much emboldened by their success against the electric light companies."

As a result of the above litigation, a better grade of insulation came into vogue, thereby decreasing the leakage from the electric light lines. Hardly was this matter settled when the street railway came upon the scene, employing an electric system that, so to speak, was all leakage. It is true that the telegraph and telephone systems that preceded it came in the same category, on account of their grounded circuits, and yet the relatively enormous current liberated by the street railway seemed to require that the overhead trolley should be treated on its own merits, and without regard to telegraph or telephone precedents.

The first electric street railway, innocently following in the lines of the telegraph and the telephone, deliberately set out to use the earth as a return path for the electricity set free at the car wheels. It was not even intended at the start to employ the rails for this purpose, except as they might form part of the general earth return. Discovery was promptly made that methods satisfactory in the case of the telegraph and telephone could not be successfully applied to the latest electrical system. Recourse was had, therefore, to bonding the rails, or bridging over the resistance of the rail joint by a wire riveted to the end of each rail. In the case of flat tram rails, a supplementary wire was run parallel to and between the rails to assist the return of the current. To further aid the track return, connections were made to gas and water pipes at frequent intervals along the line. Wherever the road crossed a water course a heavy wire was attached to the rails, the other end of the wire connecting with a piece of metal placed in the water. Eventually everything underground, whether natural or artificial, that could by any process of reasoning be considered as assisting to conduct electricity was pressed into service. At the power house one pole of the generator was connected to rails, to water pipes, to gas pipes and to ground plates.

The effect on the telephone service needs no description. Its sensitiveness and its grounded return invited it to ruin. Inductive influence of such magnitude imperilled the very existence of the telephone. The railroad differed from the electric light in this, that, whereas the latter could by a reasonable expenditure alleviate, if not

entirely remove, the evils caused by its heavy current, it was simply impossible for the railway to do so. Recourse was had to the courts.

Quoting again from John S. Wise: "In the street railways the telephone found no such weak adversary as it had in the electric lighting companies. In point of time the street railroad franchise was in most places older than that of the telephone. In point of fact, even before the discovery of the telephone, the grants of street railroad franchise had embraced the right to use any method of propulsion then or thereafter discovered except steam. In right of occupancy, the electric railways were on the public highway exercising the very use for which the highway had been originally dedicated. In the use of the grounded circuit the telephones themselves were simply enjoying the identical right possessed by the street railroads, and, in order to deny the right of the street railroad to use the grounded circuit, the telephone must itself establish that it was entitled to the exclusive use of the earth. Ordinarily, he who asserts an exclusive easement is compelled to show, not only the priority and exclusiveness of his grant or use, but the source and boundaries of his title. The telephone made no attempt at this. It merely contented itself with saying that it had used the earth for its return circuit, was using it undisturbed until the street railway did the same thing, and was injured by its neighbor's use of the ground circuit, so as to entitle it to invoke the protection of the legal maxim, *sic utere tuo, ut alienum non lœdas.*"

Judge after judge characterized the telephone claim as preposterous, and in the end the trolley won, the telephone falling back upon a metallic return. The overhead trolley employing a grounded return had come to stay.

Scarcely had the trolley ceased defending itself against the telephone, when there began to spread over the country vague and gloomy forebodings as to serious damage to the water and gas systems caused by the stray currents of the street railway. These reports came first from Boston and were put in circulation in 1891. At once the electric street railway attracted the most earnest attention of the city authorities, and these stray currents, from being a bone of contention between corporations, suddenly became a living municipal problem. Let us place ourselves at the end of the year 1894, and briefly sum up the general information in hand relative to electrolysis.

A plumber was repairing water pipes in a dwelling and had occasion to disconnect them. Upon breaking a joint an electric arc formed across the separating pipe-ends, severely burning the plumber.

In investigating the cause of a fire, the authorities were nonplussed,

until a difference of potential was discovered between gas and water pipes in close proximity. The vibration caused by passing wagons had brought the pipes into contact intermittently, thus causing an arc that burnt a hole in the gas pipe and finally set fire the escaping gas.

The workmen engaged upon the elevated structure in South Brooklyn were startled when, upon placing the connecting link in the iron work, a bright flash ensued.

The lead armor on telephone cables was eaten through in a few weeks' time.

The rails of the street railways themselves were in some localities being rapidly destroyed.

In isolated instances 6 and 8-in. cast-iron pipes were reported to have been corroded through by electrolytic action.

Manhole explosions had in some cases been directly traced to the presence of electricity on cable armors, in conjunction always with escaping gas and sometimes with moisture.

Everywhere, wrought-iron and lead services of the water system, and the mains and services of the gas system as well, began to fail.

The Edison companies were beginning to experience inexplicable burn-outs on their underground lines.

Professor D. C. Jackson, of the University of Wisconsin, had made an extended series of tests, from which he deduced the following: The electrolytic effect upon a buried pipe depends upon the resistance offered by the earth, and upon the amount of soluble salts—the electrolysis of which are injurious to the iron—that are contained therein. These salts consist of chlorides, nitrates and sulphates, the order given representing their relative activity upon the iron pipe under the influence of the electric current. Since a minute quantity of any of these salts is sufficient to start electrolytic action, and as nearly all soils contain more than mere traces of one or the other of these salts, it follows that corrosion of a buried pipe is reasonably assured.

The above citations cover the ground pretty fully. Brooklyn was well abreast of the times, both in collecting information from without, and in furnishing samples from within. In December, 1894, the Board of Commissioners of Electrical Subways wrote: "The cause of the difficulty is now well determined; the remedy for the evil will have been applied when the companies shall have provided an adequate route for the electric current now discharged into the rails."

At the end of the year 1894 the impression generally prevailed that (in the language of the Subway Commission) "an adequate route for the electric current now discharged into the rails" would result in a cessation of electrolytic troubles. The writer did not share this belief. It seemed to him that, in order to confine the return current to the rails, the resistance of the earth and contained pipes would need to be infinitely great; and this result could be attained only by making the resistance of the rail return infinitely small, which is commercially impracticable.

However, in striving for "the adequate route," the trolley companies have made great progress in the amelioration of conditions. They have at all times, in Brooklyn, at least, evinced a willingness to co-operate in every reasonable way in the adoption of such schemes as were suggested; and the heavier rails, many and large return feeders, and old rails employed as track returns, are evidences of the advanced ideas on the subject.

Indeed, the writer has been obliged to discourage in his official capacity certain measures proposed by the companies for the cure of electrolysis; and this, in spite of the endorsement of these measures by city and street railway engineers everywhere, and by the Board of Commissioners of Electrical Subways of Brooklyn. It appears that in 1894 the electrician of the Board selected the water main on Third Avenue, between Twenty-fifth Street and Sixtieth Street, for a test case. The difference of electrical potential between pipes and rails indicated a serious condition of affairs. Upon running a return feeder out from the Fifty-second Street power house and connecting it at intervals to the mains, a resurvey of the territory affected showed that the evil had apparently been suppressed. Thereupon the companies made application to the authorities for permission to duplicate these return connections elsewhere.

These applications were referred to the writer, who reported unfavorably upon them, basing his decision on the following grounds:

1. It was not settled that the city, having sanctioned this connection, would be able to recover damages in case the tentative remedy proved unsuccessful; whereas, under existing conditions, the indemnity bonds filed by the various companies were sufficient to cover the city in any damages that might be expected to occur to the water mains.

2. There was every probability that the authorization of this connection by the city would render it co-defendant with the companies in any suit for damages to service pipes that might be brought to trial. The plaintiff could with truth claim that the objectionable electricity had reached his service pipe *via* the water main.

3. Granting that lessened danger would ensue to service pipes in the locality affected by this connection, there was no certainty that the decrease in resistance caused by the bridging over of the earth gap would not result in an increased flow of current along the pipes, and consequently, an increased electrolytic action at every joint of the water main. (From later experience the writer believes that he has overestimated the probable action at the joints.)

4. The proposed remedy was in reality no remedy at all; for while the local effects might be good, the electrical equilibrium of the city would be disturbed, and electrolytic troubles would appear in new localities, thus entailing an interminable series of bondings and unbondings that would keep the streets perpetually torn up.

Thus matters stood until the summer of 1896, when the Board of Commissioners of Electrical Subways began a resurvey of the city. In a careful review of the facts up to date the writer had been struck by the absence of reports indicating damage to cast-iron pipe. Three instances only were recorded: One by J. H. Vail of a 6-in. water main from a Pennsylvania town, eaten through in 2½ years. The material composing this pipe is not stated, but the photograph as well as the inference, points to cast iron. The second, from a city west of the Mississippi, perhaps St. Louis, the inference as to cast iron being derived from the context of the report only. The third, from Memphis, Tenn, where the "burning out" of a 6-in. main is stated to have occurred. In this last instance the phraseology would seem to indicate that the electric arc, rather than slow corrosion, was responsible for the damage.

In view of these facts relative to cast iron, it was decided by the Subway Commission to devote a large portion of the work of the 1896 survey to an investigation of the condition of the Brooklyn water mains. The writer was detailed to represent the city on this work, Mr. John A. Barrett acting, as in 1894, on behalf of the Commission.

We selected more than a dozen localities where voltmeter readings had indicated that trouble might be expected, and, with the aid of the

pipe yard gang, uncovered the pipes. Sample observations are as follows:

Hydrant at rear of New York and Brooklyn Bridge dock, just north of Fulton Ferry. Positive to river, 1.4 to 2.2 volts; soil, sand and cinder, tide rising and falling through same; hydrant somewhat rusted; cast-iron branch pipe slightly crusted with rust, the usual cinder scale on the under side in spots; indications only such as might have been expected to result without electric aid; hydrant and pipe placed about 1880.

Hydrant at foot of First Street, west of Gowanus Canal. Positive to canal, 4 volts; soil, made ground; hydrant slightly rusted; adjacent wrought-iron fittings badly eaten away; pipe and hydrant placed August 23d, 1894.

In order to check in practice the conclusions of Stone and Webster, who had deduced from laboratory experiments, made in Boston in 1894, that the jumping of electricity around the joint of a water main caused electrolytic action on the positive pipe, we uncovered on Third Avenue, opposite the Nassau power house, a few lengths of 8-in. cast-iron main, coated with tar. This pipe was manufactured by the Camden Iron Works, was cast in the old 9-ft. lengths and had been in service since November 17th, 1868. For nearly three years a heavy current had been conducted along this pipe, and at the time of our test the voltmeter showed 1 volt difference of potential around each joint, or 5 volts in five lengths of pipe. In the absence of suitable appliances for indicating the current, rough calculations by several persons present fixed its value at from 1 000 to 3 000 amperes.

Four lengths of pipe, as they lay in the virgin sandy soil, were carefully inspected, and then a section, consisting of the bell and 2 ft. of pipe on either side, was taken out intact, split in half longitudinally, and the interior closely scrutinized. No pitting appeared, nor was it possible to detect by calipering any diminution in the thickness of the pipe on the plus side of the joint. But the most remarkable feature of this pipe was the clean asphaltic covering, almost as fresh on this twenty-eight-year-old section as on the new 12-ft. lengths that replaced it.

Mr. Barrett concisely stated the situation when he said: "From such an examination as we were able to make, it would be unwarrantable to assert broadly that cast iron of any particular quality possesses an

absolute immunity from electrolysis. In fact, a test applied to a fragment of cast-iron pipe in a tin pail of earth, with a drop of potential of 10 volts from the fragment to the pail, gave in three weeks undoubted evidence of electrolysis of the iron. But from a careful investigation of the facts, so far as we are able to proceed with it, I think it is at least safe to suggest that at low potentials cast iron, of such quality as exists in the water mains which were examined, will endure practically unharmed a flow of current into the earth, which, under the same conditions, is totally destructive to wrought iron and lead."

For two years this very cautious statement remained unchallenged, even though distorted by careless readers into a definite claim for the absolute safety of cast iron; and the Brooklyn officials charged with the distribution of our water supply experienced no leak in cast-iron pipe that could in any way be laid at the door of electricity.

Last summer the sense of security that prevailed here was rudely disturbed by the astounding statement of the Secretary of the Dayton, Ohio, water-works, that, to repair the ravages caused by electricity on the water mains of his city, it would be necessary to replace 17 513 ft. of cast-iron mains, at a cost of $77 000.*

It seems, then, that we must rearrange our facts, and endeavor to arrive at some other conclusions than those with which we have been satisfying ourselves for the past few years. Is it reasonable to suppose that Brooklyn soil differs so greatly from that at Dayton as to render our water mains secure while those of another municipality are beginning to suffer? Or, on the other hand, what warrant have we for assuming that our cast iron is of different composition from that furnished by the same manufacturers to Dayton? Is it saying too much, then, if one characterizes electrolysis as the most important unsolved municipal problem of to-day?

There are five distinct systems of street car propulsion by means of electricity:

1. An ideal, but hardly as yet satisfactory, system of storage battery cars.

2. A thoroughly satisfactory, but very expensive, system of underground trolleys.

3. An experimental system of electro-magnetic switches with contact plates.

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* Harold P. Brown before the American Society of Municipal Improvements, November, 1898.

4. A commercial, though complicated, system of double overhead trolleys.

5. The single trolley system, with which we are all familiar.

Now, it so happens that the only one of the five systems that has come into general use is the very one that is causing uneasiness regarding the integrity of our water mains, to say nothing of the water services, gas pipes, etc. for which the municipality is morally, if not legally, responsible. This system has prevailed thus far because it is the least complex and because it can be installed at a reasonable expense. Must the single trolley be banished? Plainly, such an audacious suggestion should be made only after every possible alternative has been exhaustively examined; and it is with a view to promoting an interest in the study of these alternatives that the writer presents this paper to-night.

The remedies that have been suggested may be enumerated as follows:

1. Better track return by means of heavier rails, larger bonds and return feeders. This remedy is being steadily applied. It is, however, a palliative, not a cure.

2. Bonding between rails and affected pipes—the intimate and general connecting together of rails, water pipes, gas pipes, subways and cable armors at the so-called danger points. This seems to be a perfect cure—in spots. That is to say, if on the first day of January this plan of bonding goes into effect, on the first of February an entirely new system of bonding is necessitated to take care of the new danger points that have resulted from the very steps taken on January 1st to effect a cure. Furthermore, there is considerable doubt as to how well the pipe joints will stand the increased flow of electricity for which this extensive bonding is responsible.

3. Auxiliary potential plan. An arrangement of dynamos and wiring by means of which the pipes, etc., are kept, or supposed to be kept, negative to the rails at all points and at all times. These arrangements, of which there are many, mostly patented, may undoubtedly prove of service in smaller cities or towns, where the conditions are not as complicated as in Brooklyn.

4. The insertion of insulating sections into a line of pipe. Usually this is proposed only for the water mains. Twelve-foot lengths of wooden water main placed in the line at intervals would greatly dis-

Copper Drip Pipe in Use in Sea Water for Seventeen Days.

Wrought-Iron Service Pipe in Use for One Year.

courage the electricity in its attempt to get home by this path. An increased burden would in this way be thrown upon the gas pipes and other conductors, and more wood pipe would be required to take care of the increased evil in a new direction.

The Wyckoff wood pipe for a complete system of water distribution has been suggested as a remedy. This pipe seems to bear a good name in certain western cities where it is in use. Still, however desirable it might prove to be for extensions, one cannot expect that the present iron piping will be discarded for wood, and it is the existing piping that primarily concerns us. The writer has not been able to determine whether the apathy shown in certain quarters toward his suggestion of three years ago to experiment with a few services of Wyckoff pipe was due to a lack of interest in the subject, or to a thorough acquaintance with the demerits of the pipe.

It has also been suggested that the use of the present cast-iron mains be retained, the electrical discontinuity of the line being attained by the insertion of an insulating washer at each joint, and by the employment of cement or iron oxide for caulking instead of lead.

It seems evident that in the fourth remedy the element of expense has been ignored. The plan proved desirable in the case of service renewals however.

On the table before you are some characteristic samples showing electrolytic effects on different materials:

1. Wrought-iron service pipe in use about one year.

2. Lead service pipe in use about nine months.

3. Lead service pipe in use about nine months, showing particularly the effect of concentrated electrolytic action. Numbers two and three were cut from the same pipe.

4. Copper drip pipe in use about seventeen days.

These four samples have been inherited from the Board of Commissioners of Electrical Subways.

5. Piece of cast-iron coupling box from the Edison underground system in use about three years, loaned by Mr. W. S. Barstow.

6. Scotch cast-iron 6-in. main in use for thirty years in a locality where electrolytic disturbances are not known to have appeared, even on wrought iron. This also may be taken as a fair sample of ordinary corrosion.

7. American cast-iron 6 in. main in use for 10 years in a locality

where electrolytic disturbances are not known to have appeared even on wrought iron. This also may be taken as a fair sample of ordinary corrosion.

8. Cast iron from the broken 48-in. main on Central Avenue, concerning which so many electrolytic hypotheses have been advanced.

It was intended to present as a sample to-night a piece of 2-in. cast-iron service pipe which had been in use for twenty-six months in a locality where its predecessors, whether wrought iron or lead, had failed regularly after five months' use. This pipe was installed by Mr. E. S. White, on January 4th, 1897, upon the suggestion of the writer, at the engine house of the Wallabout Bridge. Through the courtesy of Messrs. C. C. Martin and J. S. Langthorn, an excavation was made yesterday for the purpose of removing a sample length; but, as it was impossible to detect any evidences of corrosion, even of the ordinary variety, we decided not to disturb the service. The pipe in question lies in moist, sandy soil within 30 ft. of the tracks. It was thoroughly coated with asphaltum varnish, the joints being calked with lead, in the usual manner. Voltmeter readings, taken during the middle of the day, show the pipe to be positive to the rail, 1 volt, with no cars passing. As the conditions have been steadily improving at the point in question, the above reading probably under-indicates the severity of the electrical action that the pipe has undergone.

Our experience in Brooklyn would indicate that a very hard, dense, even-grained white cast iron, containing alloyed, rather than combined, carbon, and coated with Dr. Smith's coal pitch varnish, or some of the asphaltic lacquers that have taken its place, is probably as secure against corrosion as any existing iron product. There is a field for research in this direction, however, in the discovery of a cast iron that will not be attached by the acids set free by electric currents in the soil, and of a paint, varnish, lacquer or oxide coating that will absolutely protect the present grade of cast iron. This may sound visionary; but the experience of the underground cable people in protecting their lead armor against certain forms of decay by the addition of 3% of tin indicates at least a possibility of similar success in the matter of cast iron.

Professor Samuel Sheldon, of the Brooklyn Polytechnic Institute, is experimenting along this line, confining his attention more particu-

Lead Service Pipe in Use About Nine Months.

larly to cast iron. The writer is keeping in close touch with these tests, and is confident that they will result in interesting disclosures.

Those of you who examine the cast-iron samples closely will notice that the fractures of the non-electrolyzed samples agree intimately in general appearances. The fracture of the cast-iron coupling box, which box bears evidences of electrolysis, is of a different character entirely. Here is a clue worth following up. Our iron men ought to be heard from, as soon as they have had time to attack the samples with microscope and chemical reagents.

Gentlemen, the facts are before you; the samples that have been presented are all from Brooklyn. If the Brooklyn water authorities be criticised for not stirring vigorously in the matter, it must, at least, be acknowledged that the evidence submitted of danger to the mains is very weak. However, the Dayton case should be a warning, and, whether, through good luck, good management or for some other reason, our water distribution system remains intact, the cause of such safety must be determined.

And what of the broader field lying beyond the water supply? That, perhaps, comes closer home to each one of you. The plumber's bill for a water service, the temporary disablement of your telephone or your electric light, the manhole exploding in dangerous proximity to your person, your house set afire by escaping gas mysteriously ignited—all these might be your portion were you residing in some other city. Here you get off with the plumber's bill and are lucky.

Again, as to damage. Who is to reimburse the injured taxpayers and corporations? The trolley companies, or the men who stood sponsors for their franchises?

It is considered proper, in papers of this nature, for the author to apologize for bringing forward a distasteful topic and to earnestly deny in advance the mere imputation that he is an alarmist.

If to consider this particular subject of electrolysis seriously, impartially and with due regard especially for its possibilities for evil, is to be an alarmist, then the writer certainly is one. There are to-day appearing in the public press articles as unjust as they are sensational, articles calculated to make the layman believe that his only safe course lies in building his own well, placing his dwelling on piles, lighting it by kerosene, and protecting it by a family fire department. The writer has been called upon from time to time to

prepare refutations of these sensational stories, and this paper owes its existence to his ability to do so. One cannot refute without advancing counter arguments. The silent testimony of these samples on the table is unanswerable. With the exception of cast iron, the evidence is all in favor of rapid injury caused by the electricity in the earth. The negative testimony of the cast iron, however, does not permit us, in the face of the Dayton experience, to hold that past immunity necessarily implies future safety. The Dayton pipe failed after four years; ours may fail after ten.

Wrought iron, lead and copper pipes are very susceptible to electrolytic corrosion; we are sure of that. Cast iron holds forth some hope that, under circumstances which we may control, it can be made safe from this kind of corrosion. But we do not know this; we are merely assuming it. The assumption answered very well so long as there were no proofs of its falsity to confront us.

We are now called upon to plead to the definite charge that the water distribution system of this borough is dangerously near collapse. Is the case to go to the plaintiff by default? Or shall we confess judgment? Or will it be best to get our evidence into shape, and stand trial?

By all means, get the evidence into shape. It ought not to have been possible, at this day, for the public press—aye, and even electrical experts—to attribute the breaking of a water main on Central Avenue to electrolysis without being met instantly by an array of refutatory facts, gained from painstaking and repeated investigations.

This paper, then, is a plea for electro-chemical research as to the exact cause of the corrosion, as to preventatives and cures by means of additional wiring, or the adoption of systems of street car propulsion other than the single trolley; as to the discovering of alloys that are not affected by present conditions. We need to know, and to know promptly, whether the decay of our cast iron is slow or rapid? Whether it is due to ordinary corrosion entirely, or to corrosion accelerated by the action of stray electricity, and, if due in any measure to electricity, to what extent and why? Whether the composition of the soil, or of the cast iron, is the controlling feature?

Bright minds have been at work upon the problem for several years, and yet the solution has not arrived. This result is attributable

Cast-Iron Gas Main in Use Many Years.

largely to the lack of that comprehensiveness of action which can only be gained by the united effort of many minds working together.

As matters have stood heretofore, an expert arises in the convention and reads a report detailing the situation as to electricity in town A, and explaining, possibly, what measures have been adopted to prevent further trouble. At some other convention another expert takes the floor and describes his experience with electrolytic corrosion in town B. A third expert publishes the results of his experiments with bits of metal buried in tin pails full of earth from town C, or with an iron pipe in a wooden trough. A gas works manager relates that his company in town D did have trouble with leaky pipes, but that the railway people connected a few wires to the pipes, and the trouble had disappeared.

Understand, there is no attempt made here to belittle the importance of these papers or reports. Mention is made of them merely to show that, while forming valuable additions to technical literature, they are not contributing very largely toward any solution of the whole problem. We can to-day get some facts from a great many towns; what we require is all the facts from one town.

And, bearing in mind that our attention must be directed initially to the specific case of cast iron, let us not lose sight of the broader problem. Is it just for us to lend our energies solely to the safeguarding of our water mains, allowing the other interests affected to work out their own salvation, and to arrange directly with the railway companies as to payments for past injuries and as to preventatives for the future?

If there be a solution of the problem, other than the discarding of the single trolley system, entirely, it is probably beyond the grasp of any one mind, or of any number of minds acting independently, and can be arrived at solely by concerted effort on the part of the street railways, the municipal authorities and the corporations whose plants are suffering. A commission formed on the lines here laid down, and composed of one technical representative from each of the interests affected, could reasonably be expected to settle the whole question once and for all.

The suggestion is ventured that the Brooklyn Engineers' Club, in in the absence of a commission, can do yeoman work in a preliminary way if it so desires. Will you limit your interest in electrolysis to the ensuing discussion?

DISCUSSION.

Mr. Brown. Mr. ROBERT P. BROWN.—I would like to ask Mr. Wynkoop what condition Milwaukee is in at the present time.

Mr. Wynkoop. Mr. H. S. WYNKOOP.—I do not know. I have taken the stand that we gain very little by getting a job lot of reports from other towns. I have been through that mill until I am perfectly bewildered. I get a little information here and a little there; and I have made up my mind that until somebody establishes an information bureau that will get all the reports from all these towns it would be hardly worth while to go into the matter. I do not know what the conditions are in Milwaukee at present. I haven't heard from there in two years. At that time they were having more or less trouble of one kind or another.

Mr. Brown. Mr. ROBERT P. BROWN.—It has been claimed that the conditions in Brooklyn about six years ago were a great deal worse than at the present time.

Mr. Wynkoop. Mr. H. S. WYNKOOP.—In speaking of the refusal to permit bonding to water mains, I gave my reasons for so doing. I do not want to be taken as believing personally that such a thing is not a help. I think that if the bonding were carried out universally, that is to say, if it took care of everything, water pipes, gas pipes, and everything in the neigborhood that needed attention—it would probably be a pretty good thing. But the Department couldn't very well permit that, for the reasons given. Mr. Brown is undoubtedly right in saying that this bonding is a help. I cannot see how it can be an absolute cure, however, as he seems to consider it. I made the statement that it is a palliative, not a cure, and gave my reason; I don't see how you can very well consider it as anything else. As long as there are any service pipes failing, there will be more or less doubt in the public mind as to the condition of all the pipes in the Borough of Brooklyn.

Now, the main point of this whole discussion is the showing up of the fact that we don't know how to answer the public. Nobody has ever taken up this matter in such thoroughly comprehensive shape as to be able to reply to these sensational arguments. We can state that this remedy has been applied here, and that remedy there—to one pipe or another. By the time a person gets out his statement that the trouble is stopped, a newspaper article comes out, detailing a recurrence of the trouble in another spot where the remedy was supposed to have proved effectual.

Mr. Meem. Mr. J. C. MEEM.—Referring to the statement about cast-iron pipe, I saw some cast-iron pipe in Wilmington unquestionably affected by electrolysis—one 6-in. and a 4-in. section, I think. Out of curiosity I examined them. I think one of them had three or four holes in it just as if they had been bored out in that shape.

I would like to ask, if it is absolutely necessary to protect a pipe, whether it would not be simpler to lay a heavy copper wire along in connection with it. Wouldn't that prevent electrolysis? Mr. Meem.

Mr. H. S. Wynkoop.—I do not see how it could. By putting a copper wire there you would simply be furnishing another path for the electricity, and wherever the electricity actually got off the copper it would be apt to get off of the lead, wrought iron or cast iron, at the same time. Mr. Wynkoop.

Mr. J. C. Meem.—I was merely asking for information. Wouldn't electricity follow the copper wire in preference to following the pipe? Mr. Meem.

Mr. H. S. Wynkoop.—Electricity will follow the pipe almost as readily as the wire; and in that case you would get electrolysis of the copper wire and electrolysis of the cast-iron pipe, or wrought-iron pipe or whatever it might be. If, however, you carry the copper wire directly back to some legitimate conductor, such as a rail or return feeder, or something of that sort, then you practically stop all electrolytic action. Mr. Wynkoop.

Mr. J. C. Meem.—They would have to be connected then? Mr. Meem.

Mr. H. S. Wynkoop—Certainly. That is, generally speaking, the scheme that is carried out in this bonding that Mr. Brown spoke of. The idea is that if there is a tendency for the current to leave a pipe it is only necessary to put a clamp and a bond on the pipe which the current is leaving in order to carry away the electricity without affording any great chance of electrolysis. Mr. Wynkoop

Mr. J. C. Meem.—I think that was done in Wilmington, too. Mr. Meem.

Mr. H. S. Wynkoop.—Yes, that has been done all over the country. I think that Brooklyn has held back more than any other city that I know of in that matter. Whether we were wise in doing so or not remains to be seen. We have certainly dodged a number of lawsuits just by our action in that matter. Mr. Wynkoop.

Mr. J. C. Meem.—If there is a good return wire between the rails, does not that come nearer solving the problem than anything else? Mr. Meem.

Mr. H. S. Wynkoop.—It would help; but, as I say, you cannot get rid of the electricity on the pipes until you have an infinitely low resistance by a legitimate return. Otherwise, the current is bound to split up, part following one path and part following another. Now, the lower resistance of the legitimate return, the more current will follow it and the less will take the other path through the pipes. But even assuming that the companies spend millions of dollars in returns, they would still have an appreciable resistance in their return circuit. You never could get that perfect. Consequently, some electricity would follow the pipes. Mr. Wynkoop.

Mr. George W. Tillson.—Can't you have a return wire that would carry the electricity back to the power house without touching the earth at all? Mr. Tillson.

Mr. Wynkoop. Mr. H. S. Wynkoop.—That is being done now. The greater part of the current would go back through the return wire; part of it would go back through the earth. Only one town in the country has stuck it out in the matter of an insulated return.

Mr. Tillson. Mr. George W. Tillson.—How about the underground system in Manhattan? There is no trouble with that.

Mr. Brown. Mr. Robert P. Brown.—No, though occasionally the insulation breaks down.

Mr. Tillson. Mr. George W. Tillson.—What I mean is: The real cause of the trouble is owing to the fact that the electricity escapes from the conductor into the earth. From the rail it gets into the earth, and then is scattered over these different pipes. If it were practically and financially possible—I mean by financially possible, practicable—to confine this current, then there would be no trouble.

Mr. Brown. Mr. Robert P. Brown.—As a matter of fact the percentage that does reach the pipes is very small, because iron pipe has about six times the resistance which a cross-section of steel rail has. I think it is a little higher. Almost any combination of water and gas pipes and other things considered does not offer as great sectional area as the rails in a great many of the streets.

Mr. Tillson. Mr. George W. Tillson.—I was reading a report of the American Water Works Association, I think it was last year, in which they recognized the fact that it was impossible to do away entirely with electricity in the pipes, and they recommended a system of smoothing off the pipes at intervals that might be decided to be necessary, and then putting clamps, such as Mr. Wynkoop spoke of, around those places that had been smoothed so as to get a good contact, and then fasten the clamp by a copper rivet, and then connect the rivet to the rails. I was interested particularly in that, because it was a suggestion that came from the Water Works Association to use the water pipe, which they seemed to think would give no trouble.

Mr. Meem. Mr. J. C. Meem.—Is there any leakage from the underground trolley?

Mr. Wynkoop. Mr. H. S. Wynkoop.—Not to amount to anything. The leakage due to bad insulation of underground trolleys is right among their yokes, and if the breakdown is on one side the chances are the other side will give way somewhere in the neighborhood, and the double break enables the electricity to jump down, go down a yoke or two, and come up on the other side, and so it is all self-contained. The only property that gets damaged is the property of the company itself. That is my impression, of course. I have had no direct experience with underground trolleys. Mr. Knudson's paper of last fall seems to show that there is no such thing as leakage of any importance from the underground trolley.

Mr. Brown. Mr. Robert P. Brown.—I don't like to hurt anybody else in this. I am a little puzzled why Mr. Wynkoop did not carry that point a

little further, and say the greater part of Mr. Knudson's report was based on the assumption that the leakage came from the electric light systems and not from the trolleys. Mr. Brown.

Mr. H. S. Wynkoop.—I did not intend to conceal that fact, because Mr. Knudson did prove something against the electric light company. However, I thought it irrelevant, and left it out. But he did prove conclusively in his tests, however, that the great leakage he found uptown was due to the Union Railway Company; for he got the company to shut down their line, and the little leakage that still remained he traced directly to the Edison Company. Mr. Wynkoop.

Mr. Robert P. Brown.—That was uptown where those tests were made, particularly because at that time the Lenox Avenue line was the only one running. Tests were made before any extensions were put on, and that district was the one that was operated. But, still, if you notice, his tests for a portion of the city, particularly in the neighborhood of the Edison station, show the existence of as bad positions as anywhere in Brooklyn. Mr. Brown.

Mr. H. S. Wynkoop.—You mean as bad as any place the city officials are supposed to know about. I would like to say, Mr. Brown, you, also, seem to suffering from loss of memory in a small degree. You don't mention the fact that Mr. Knudson discovered trolley leakage down in the neighborhood of Park Row, on the bridge cables, etc., and he attributed that leakage entirely to the Brooklyn trolley companies. Mr. Wynkoop.

Mr. B. P. Legaré.—Are there any reports about breakage of pipes, etc., in the neighborhood of Hamburg Avenue? Mr. Legaré.

Mr. H. S. Wynkoop.—No; the curious thing is that nobody seems to be seriously investigating. The telephone company, when I talk to them, say they are satisfied. If I talk to the gas company, they say that they have just employed experts, and are going to suggest remedies; that the experts of the trolley companies are working in harmony with them, and they are going to attend to the gas mains. The city officials say that our cast-iron water mains are perfectly safe, so what is the use of caring about the other pipes? Nobody seems to know. But, I presume that the Hamburg Avenue case could be classed almost with the Central Avenue case. Mr. Wynkoop.

Mr. B. P. Legaré.—No, it wouldn't; not quite; for the reason they don't have any bond at all. Mr. Legaré.

Mr. H. S. Wynkoop.—I had a definite statement two weeks ago from the men at the pipe yard of the Department of Water Supply, to the effect that they, in their past experience, had found no case whatever of a break in a cast-iron main that was any different in appearance from the old-fashioned breaks they used to have before the trolleys came into the Borough of Brooklyn. There is not a case of electrolysis on record in the Department of Water Supply, and these Mr. Wynkoop.

Mr. Wynkoop. men are the fellows who have been a good many years in the department, and have had experience in all the different kinds of pipes, and know pretty well what a pipe ought to look like when it has been in the ground for some years. Does that cover the point that you wish to make, Mr. Legaré?

Mr. Legare. Mr. B. P. Legaré.—Not exactly. It is entirely different. We have had a good many cases from other places. The answer of the public when there is a broken pipe is: "Go and fix it." Of course, it is well known that railroad companies would do those things and the city wouldn't.

Mr. Wynkoop. Mr. H. S. Wynkoop.—The current went back probably on the water pipes largely. I do not think that it is fair that the burden should be thrown on the railroad companies. But it is at present, and has been in the past. I think the matter should be taken up systematically and comprehensively by the authorities.

Mr. Martin. Mr. Martin.—I was very much interested in this paper; and I heartily agree with Mr. Wynkoop that it would be of the greatest value if this subject was thoroughly investigated and a report prepared, so that we would be able to say that certain conditions had been compl'ed with, according to certain reports, and, therefore, we are safe. I had occasion to notice how much we were influenced, and how many people were frightened by reports of electrolysis in connection with the Brooklyn Bridge. At times the newspapers have made reports that the bridge is in danger; and the people have actually taken to the ferries. Traffic has increased on the ferries and fallen off on the bridge, in consequence of such reports. Perhaps it might be interesting to know some of the reasons why the bridge is safe.

As Mr. Wynkoop says, cast iron seems to be quite free from the effects of electrolysis, and it happens that the plates of the Brooklyn Bridge are cast iron. They are about 13-ton cast-iron plates. I notice in the new bridge that they have some steel plates; but they are evidently going to have a mass of wrought iron, but in their plates, as in the Brooklyn Bridge plates, they are going to be thoroughly covered in with cement, and that brings me to the second point, the anchor plates. These plates are cast iron and are to be covered in with cement to such a distance from the surface that there will be no acids present there. However, we have lots of current on the bridge. No doubt the bonds deteriorate. Of course the rails of the trolley tracks are laid on wood, and there can only be surface leakage over the bridge structure. We investigated that matter, and concluded that the best way to meet that was to provide a return circuit back to the power house. For that purpose we connected the trolley tracks with the bridge railroad tracks. That gave double tracks with deep rails for carrying the current to a point which we selected, which was the tower, so that the trolley tracks are connected right straight across to the bridge tracks. At the bridge

tower we dropped a couple of large cables into the river, and connected those with the plates. Mr. Martin.

The first plates put in were of wrought iron, and they disappeared in about two months, and also a copper wire leading to those plates. We have now substituted for that a 12-in. cast-iron pipe that will probably last longer. We have also had one other connection off the bridge, that is, the pneumatic tubing. You see, we don't allow the trolley tracks to rest on or be in any way connected with the bridge structure. We connect them to the bridge railroad tracks, but they, in turn, are insulated by the ties from the bridge structure, so that we try to keep the trolley tracks insulated from the bridge strncture itself. But the bridge structure is connected very thoroughly with those pneumatic tube pipes, so that whatever current does get on to the bridge structure is promptly conveyed off by those pipes, and has no tendency to go down the cables and anchor plates. Before we made this connection to the river our tests showed that there was a difference of potential on the Brooklyn side of anywhere from four to six volts between the trolley tracks and the water of the river. Just as soon as we made these connections into the river the difference of potential dropped very appreciably on the bridge, and showed that the wires were doing good service in cutting down the difference in potential.

Mr. Willard S. Tuttle.—I would like to ask Mr. Wynkoop if the favorable impression that cast iron has produced is not in some way connected with the surface of the pipe. For instance, you will find that the lead pipe and the wrought-iron pipe have comparatively free, pure metallic surfaces. Cast-iron pipes are most, if not all, of them coated with asphalt, which is a sort of insulation. Also, that the coating that is formed upon the casting by a sort of oxide of iron or silicate combination protects the casting a great deal. You remove that scale, and the casting will rust much quicker. You leave that scale on, and the casting is more durable. Mr. Tuttle.

Mr. H. S. Wynkoop.—In connection with that I will say that the matter has been brought up in the past. We tried to get as near to a solution of that as possible by this case of Washington Avenue. The conditions there were at one time extremely unfavorable. That was due to a combination of circumstances for which the trolley companies were not really responsible. We had fifteen volts at one time there while the tracks were all torn up, and the return feeders were torn to pieces. It was at this time that we found our wrought-iron and lead services were failing rapidly. That is to say, they failed most rapidly at that period, although they did fail quite rapidly at other times. Mr. Wynkoop.

I got the smallest cast-iron pipe that the plumber could furnish, 2 ins., and put that pipe in; and, as I say, that pipe has been there twenty-six months. It was uncovered and found in such good condition that there was absolutely no use taking it out.

Mr. Wynkoop. In regard to the statement as to asphalt lacquers or coating that Mr. Tuttle has spoken of as being present on cast iron, I would say that those remedies have been applied in the form of commercial varnishes to wrought iron and lead, and they have not proved efficacious. The very large surface of the cast iron undoubtedly aids in protecting it; but we cannot lay the immunity from trouble on cast iron to the fact that the surface is so much greater, because this immunity from corrosion is a peculiarity of cast iron generally. In England they find that a good grade of cast-iron pipe when used in salt water under the influence of the rise and fall of the tide lasts indefinitely. Cheaper grades will not last indefinitely. The Subway Commission, I believe, brought that out in their report four years ago, quoting from some prominent civil engineer who said that the good grade of white cast iron would stand indefinitely in salt water. He mentioned conditions under which the cheap grade of cast iron had gone all to pieces and the white cast iron remained. However, we don't know how safe the white cast iron is electrolytically. We haven't been able to find very many cases of its failure from this cause. That was the main reason I brought the samples down to-night. You will notice that the fracture of the sample that has been corroded is decidedly darker, and lacks largely the metallic luster of the fractures of the unattacked iron.

Mr. Strachan. Mr. Joseph Strachan.—In regard to the tramway work that the author spoke of, if the greater part of the current had gone back over that pipe would that explain the immunity of the pipe from failure? As I understand the trouble, it comes from the current going from one conductor to another, that is, that the effect is due indirectly to electricity, the electricity making a sort of a deposition of sulphates in the soil, and other matters, and so causing acids to work directly on the pipe, thus making electrolysis an indirect effect of the electricity. Now, I suppose if the total absence of fish plates or any connections caused the greater part of the electricity to pass back on that pipe there would be no passing and repassing from the pipe. Would that possibly explain the immunity of the pipe?

Mr. Wynkoop. Mr. H. S. Wynkoop.—It would be very apt to do so. In that case the only thing we would want to investigate would be the condition of the joints. Now in Milwaukee they found resistance of such cast-iron pipe joints as they measured to be very low. In other cities where they have made similar measurements the resistances were found to be very high. In both cases lead caulking was employed. If the electricity could pass readily along the pipe line there would be absolutely no chance for electrolysis. The only damage that could happen would occur at a joint of high resistance.

A Member. A Member.—I want to ask Mr. Wynkoop how high the difference in potential would have to be to cause electrolysis?

Mr. H. S. WYNKOOP.—We have a lot of conflicting information on this subject. Some say 3 or 4 volts, some say 10. Under certain conditions that might occur in the soil $\frac{1}{10}$ or $\frac{1}{20}$, or, perhaps, a smaller fraction of a volt pressure would cause electrolysis. Mr. Wynkoop.

Now, in England they are handling the matter by limiting the voltage that may be permitted to exist between the water pipe and the rail. I think it is somewhere in the neighborhood of 2 to 4 volts.

Mr. F. S. WOODWARD.—We, of the Edison Company, are naturally on the lookout for the effects of electrolysis and take voltmeter readings. I think the maximum reading, as I remember it, on the cables along Fourth Avenue was between 8 and 9 volts; and we found that pressure varying at different times in the day. We took and bonded the cables at a point where the voltage ran highest, and ran return feeders down to the power house on Thirty-ninth Street and Fifty-eighth Street. That seemed to drop the difference in voltage along the line as between our lead-covered cable and the neighboring lamps. Mr.Woodward.

Mr. H. S. WYNKOOP.—The telephone people are, in some instances, carrying 150 ampères away from their lead armors. You see they have no joints in the system, and consequently they can take care of that current. It goes along harmlessly on their lead armors, and they are simply furnishing the lead armor to the railway companies as an additional track return. These methods are all right in their case; but they don't know what damage they are doing to somebody else. They are looking at it from a selfish standpoint. Mr. Wynkoop.

A MEMBER.—A point has occurred to me which, perhaps, will throw some light on the apparent immunity of the cast iron under certain conditions. The author of the paper has spoken of cast iron in Brooklyn not showing the bad effects of electrolysis, and Mr. Meem has spoken of several pipes in Wilmington which did show such action. It occurred to me that perhaps the proportion between good and poor conductors in a given city would explain that difference; that in a city, in which the proportion of good conductors was very great compared to the amount of cast iron in the ground, the cast iron would not show so much the effects of the current. A Member.

Mr. H. S. WYNKOOP.—I question whether the proportion does not hold reasonably close in all cities; for, though we have a very much larger feeder return system here for our trolleys, we also must have a much larger water distribution system. Mr. Wynkoop.

Mr. F. S. WOODWARD.—My recollection is that each one of the different metals requires a different voltage for starting the decomposition; and that after it is once started a slightly lower voltage can be used. The voltage that occurs to my mind is, in iron, somewhere between 2 and 3 volts to carry on a deposition or plating, as we might look at it. The voltage stated, I think on authority of Professor Thompson, was somewhere between 5 and 6 at the beginning, and then dropped Mr.Woodward.

Mr. Woodward. down to between 2 and 3; so that if you could keep the difference in potential lower than that no trouble would result anywhere.

Mr. Brown. Mr. Robert P. Brown.—That would depend on the material of the pipe and the density of current flow and also upon the soil.

Mr. Woodward. Mr. F. S. Woodward.—He claimed, no matter what the density was, if the voltage wasn't high enough, no action would take place.

Mr. Wynkoop. Mr. H. S. Wynkoop.—How about Dr. Fleming's latest report on the subject? He has knocked out all the recognized notes in regard to the electro-chemical equivalent of wrought iron. He weighed the samples after he had passed between them a known quantity of electricity at a certain voltage for a certain length of time. When he got all through he found the losses to be in excess of what could be accounted for by any electro-chemical formula. He tried a number of voltages—perhaps from 1 to 5 volts—something like that. It isn't a question of voltage at all; it is a question of the oxide on the pipe, a question of moisture in the soil and of salts in the soil; the voltage is merely an accessory. If you can get all the conditions right, you may get electrolysis; whereas under other circumstances you can't start electrolysis on 10 volts. Your figures probably hold good in some cases; I don't think you will find them universally true.

BROOKLYN ENGINEERS' CLUB.*

No. 18.

PLANS AND SPECIFICATIONS.

A Discussion by Edwin Duryea, Jr., M. B. E. C.; Walter V. Cranford, Assoc. M. B. E. C.; and E. Conway Shaler, M. B. E. C.

Presented April 13th, 1899.

Mr. Edwin Duryea, Jr.

Specifications are written by the engineer to define the quality of work he wants, and from his point of view are supposed to show the lower limit of quality, as "not poorer than," "at least as good as," etc. They are used by the contractor more in making up his bid than at any later period, and from his point of view are construed as the upper limit of quality, as "not better than," "at least as poor as," etc.

In practice, due to the usual tendencies of human nature, the contractor's view is the one which holds on the actual construction, partly because it is common for engineers to specify more than they absolutely insist on having, but mainly because the contractor will always refuse to do better work than the specifications call for, though not usually adverse to doing poorer.

Specifications can not be considered alone. They must be taken in conjunction with the inspection, which is their final interpretation and enforcement. Almost anything is subject to honest differences of interpretation, while the enforcement depends largely on the personal qualities of the inspector.

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

Aside from interpretation, there are many kinds of work of which the desired quality can hardly be described in writing, notably the finer kinds of finish in stone-cutting. This difficulty is sometimes met (as by the New Croton Aqueduct Commission in their specifications) by specifying that the quality must be equal to that of a sample preserved in the office of the Chief Engineer, or to some finished piece of work in the vicinity. (Sample wall, Croton Gate-House rubble facing, etc.)

When no such samples are specified, and dependence must be placed entirely on the written specifications, the result is not fixed, but depends directly on the personal judgment of the engineer in charge. He will probably resort to the sample method at once and fix the quality by pointing out special cases to his inspectors—"this must be rejected," "that will just pass," "this is satisfactory."

It is especially necessary that specifications be very clear as to methods of measurement. Much trouble, and often litigation, is caused by any ambiguity in this respect. The old method of paying "extra haul" on railroad excavations after a certain haul from the center of gravity of the cut is an instance of this. While the center of gravity is a mathematical point, it is an imaginary point, invisible, and measurements based on it are too likely to result in disagreements and disputes. A much clearer and better way was in use on a railroad on which I worked in the West; here all hauls were measured from the mouth of cut, and no "extra haul" was paid except for hauls over 1 000 ft.

Another instance in which care should be used is in specifying how stone for masonry shall be paid for. There are three ways in common use: per cubic yard of actual completed masonry, per cubic yard of actual stone (water-displacement) in the masonry, and per cubic yard of the smallest rectangular block which will just enclose each stone. The three methods give materially different quantities, and I have known serious disagreements to arise from specifications not stating clearly any method of measurement.

Timber constructions are also a class in which methods of measurement need to be closely defined. The term "per M" may be construed variously, with differences of 10% or more in some structures taking much framing and using sized timber. But the

term "per cubic foot of timber left in the work" admits of no difference of opinion.

In sinking piers by the pneumatic process, it is quite usual, in the West, to pay for the sinking "per cubic foot of excavation, to be computed by multiplying the base of caisson by the distance of cutting-edge below standard low water." This is very definite, does away with any consideration of changes in the river-bed, and allows a uniform price to be used over the varying sized piers of a bridge.

Methods of payment may sometimes be specified that will give the contractor an incentive to do the difficult parts of his work more thoroughly. In pile-constructions, a smaller price per lineal foot for "piles cut-off" than for "piles left in the work," or a price for the latter item only, will nearly always result in the piles being driven deeper. It is for a similar reason much easier to get good foundations for railroad culverts, etc., if the specifications provide that "excavations below water shall be paid for at double, or preferably treble or quadruple, the actual quantities."

Specifications may also be drawn so as to prevent unbalanced bids, which it is sometimes expedient to do. As an example, the New Croton Aqueduct for many years called for a price for masonry laid in natural cement mortar, and for an additional price when Portland cement was substituted instead. The bids for this additional price were generally excessively high, much greater than the actual additional cost, so in the specifications for the New Croton Dam and the Jerome Park Reservoir it was provided that the addition should be fixed as a specified percentage of each bid on masonry with natural cement mortar.

The most sweeping attempt of this kind to prevent unbalanced bids occurred in New Jersey a year or two since, when the contract and specifications contained a balanced schedule giving a fixed price for each item of the work, and the bids consisted only in each bidder giving the percentage of this schedule for which he would do the work.

The "lump sum" method of paying for work is used in some contracts and specifications, but it seems to me that the "unit price" method is greatly to be preferred. The former seems much in favor with financiers and non-technical men, mainly because they think that in this way a fixed and definite cost for the work is insured from

the beginning. This often fails to be the case, however, and there are, besides, many pieces of work on which a "lump sum" bid can hardly be made intelligently. There are two very bad features in the "lump sum" method. In the first place, lump sum bids should always be higher than itemized ones, because there is nearly always some uncertainty as to quantities, and no intelligent contractor can be expected to do otherwise than to cover this risk by his bid. Secondly, it is very often desirable during the progress of a piece of work to make slight changes in the plans or to make additions to the work. This it is very easy to do when the work has been let by "unit prices," but if by "lump sum" the least change, unless in the interest of the contractor, is likely to cause bad feeling, and no addition can be made except by making a separate contract or by some agreement as to extra work. The only advantage claimed for the "lump sum" method, that the cost is known definitely beforehand, is seeming only, as an engineer's careful preliminary estimate of quantities, combined with the unit price bids, will give as close a result. But it is often very hard to convince others that this is the case.

In writing specifications, care should be taken not to specify impossibilities or impracticabilities. I have known carefully drawn specifications to err in this respect. (Headers and narrow pier). It is also very important that nothing be omitted, as the specifications form the basis of the agreement and should therefore state clearly all the work to be done under it. There are two sure means to guard against omissions—to review carefully in the mind all the operations of the work in their natural order and see that each is provided for in the specifications; to consult, in making your specifications, all earlier ones you can obtain which relate to similar work.

Most good specifications are matters of growth, of gradual improvement on previous ones. The execution of almost any piece of work will reveal particulars in which the specifications can be improved, and will thus tend to perfect the specifications for future work. For this reason it is a great safeguard in making new specifications to do so with former ones at hand, as the older ones may generally be supposed to have had many bad points weeded out and many omissions supplied.

In the opening paragraph it was said that specifications were regarded by the engineer as fixing the lower limit of quality. They

are so worded, but as a matter of fact they often specify more than the engineer intends to actually insist on in all cases. From general considerations, it would seem best to include nothing in specifications which it is not intended to always enforce (concrete stone, sharp sand, concrete layers, embankment layers, pile-driving, etc.) and this course should certainly be followed in a general way. However, since in practice all contractors use the specifications as an upper limit only, and most inspectors have become used to this view, an engineer must usually ask for rather more than he wants in order to get as much.

To conclude, specifications are a part of a legal instrument, of an agreement between two parties as to the performance of certain definite pieces of work. The essence of all legal agreements is mutual understanding. It is evident that specifications cannot fully perform their purpose unless they state fully, without omission, every piece of work which is to be done, and its desired quality, and, moreover, unless they do this in language so plain and explicit that but one meaning can be deduced from it.

Mr. Walter V. Cranford.

The preparation of a specification is of great importance to all the parties at interest; to the purchaser, the engineer or architect, and the contractor. It is important to the purchaser, for it describes the work to be performed, how it should be performed and the kind of materials to be used. It is obvious, therefore, that the more carefully a specification is drawn, the more fully it states the requirements of the purchaser, the more completely it deals, both in its general clauses and its details, with the work to be performed, the more likely the purchaser is to get the work done honestly and in accordance with his wishes and requirements. One of the most frequent causes of disputes between purchasers and contractors is the specification which is general in its character, which, after describing in very general terms some detail, ends up the clause by "and all to the satisfaction of the engineer or architect."

It is important to the engineer or architect, because, if it is carefully drawn, it makes his duties less arduous, it prevents disputes and renders his relations, both to his client and to the contractor, very much more agreeable. But as I understand the wishes of the Committee, they desire that I should present, at this meeting, the contractor's

view of what is necessary in a specification. I have therefore run over its application to purchaser and engineer and will endeavor to give the contractor's view of what is necessary in a satisfactory specification.

In the general clauses of a specification it is usual to state in a general way the object to be attained by the contract, the requirements which must be complied with in order that the proposal can be accepted, and in order that the bids can be figured on a common basis. These clauses are generally sufficiently full to enable a proper understanding of the character of the work, and are fair for all the parties in interest. As we come to the body of the specifications, however, it seems to me that they cannot be prepared too carefully, or go into too great detail in describing the work to be performed, and should be supplemented by plans showing the work as it is intended to be on completion.

No one thing contributes so much to disputes and misunderstandings between purchaser and contractor as faulty and meager specifications. The engineer in preparing specifications cannot exercise too much care or describe too minutely the manner in which he desires the work to be performed. A little time spent in drawing up the specifications renders his labors comparatively easy and no fault can be found when he insists upon the work being done in accordance with the clear wording of the agreement.

It is too often the case, however, that the engineer regards the contractor as an individual with whom he is bound to quarrel. That his duties are only to look after his client's interest and to get as much out of the contractor as possible. This, I think, is a mistake. It is true that the engineer or architect is directly employed by the purchaser, but, nevertheless, he has duties to the contractor as well. He is, as a rule, made the arbiter or judge of matters under dispute, and it becomes his duty, in the equity of things, to see that the contractor is also protected. It is here that the clearness of detail in the specifications is of great importance to the contractor. It defines the character of work to be performed, and if he has been foolish enough to expect that the work can be done in a manner different from that described in the specification, he cannot complain if he is obliged to do the work in a proper fashion. But unfortunately, too many specifications are vague in just this particular.

I remember an instance in which this was clearly shown. The work in hand was the building of a house. The specifications for the trim described a simple pine trim of a given breadth and thickness and made to the specification of the architect. Now, the opinion of the builder and the architect as to what comprised a simple pine trim were two very different things. The contractor had in mind a trim that could be purchased at the mill from stock patterns and at a very much cheaper cost than that which the architect desired. The result was inevitable. The contractor felt that the architect was obliging him to furnish something very different and more expensive than what he figured on; at the same time the architect was well within the limits of the specifications and the contractor had to comply with his demands.

There is another point to which I wish to allude, and that is the practice of those interested in the preparation of specifications to call for certain work of an unknown quality to be performed, where the compensation is to be included in the price named for another and distinct item of the work. To the inexperienced bidder this sometimes is regarded as of not much importance, and he makes no allowance for it, but in these times of low prices, these items do count a great deal in the aggregate, and, on some work, may prove to be just the difference between profit and loss.

In conclusion let me say, that it seems to me the contractor's interest is too often lost sight of in the preparation of a specification, the idea being to protect the purchaser absolutely and often at the expense of what appears to be just and fair business methods. I believe that should the contractor's interest be taken more into account and the specifications be drawn in such a manner that there could be no misunderstanding as to their intent, the relations between purchaser, engineer and contractor would be more agreeable and friendly and better results be obtained in the performance of the work under the contract.

Mr. E. Conway Shaler.

Engineering specifications consist of a series of specific provisions, each one of which defines and fixes some one element of the contract. These clauses relate, in general, first, to the work to be done; second, to the business relations of the two parties to the contract.

First.—They explain the plans, if any, and define the character of materials and methods to be employed on the work, or, if there are no plans, they embody the principles and rules in accordance with which plans must be drawn and the work executed. In this sense specifications enable the bidder to estimate the cost of the proposed work, and, after the contract is let, they serve as rules of inspection and acceptance of such work.

Second.—Specifications define the rights and duties of the two parties to the contract to each other and embody proper provisions for changes in plans and for settlement of disputes which may arise. They also describe the conditions of payment, acceptance, etc., etc.

There are three general classes of engineering specifications :

(*a*) Specifications accompanying complete detail plans.

(*b*) Specifications accompanying general plan only.

(*c*) Specifications unaccompanied by any plans, and commonly known as general specifications. All of the above are in common use, and each has its own particular sphere of usefulness.

(*a*) When the design is novel or the engineer wishes a particular design carried out. In the case of public works the law requires open competition and also specifies that the work be let to the lowest bidder; this necessitates full plans to avoid an inadequate or inferior design being put into competition with better ones and, from its diminished cost, receiving the contract.

(*b*) When the bidders are limited to a selected class of contractors, who have reputations to lose if they do inferior work, the engineer may prepare very general plans only and allow the contractor to submit the details in accordance with the requirements of the specifications and the approval of the engineer.

(*c*) When the contractor furnishes his own plan with his bid, provided the finished work answers equally well certain prescribed demands.

Specifications are composed of two clauses, general and specific. General clauses relate to the business portion of the contract, or define the relations of the parties to the contract as a business proposition. Specific clauses are descriptive of features of design, either explaining plans, materials to be used, or the methods to be employed.

General clauses may relate to any or all of the following subjects:

(1) Time of commencement, rate of progress, and time of completion of the work.

(2) As to the character of the workmen employed.

(3) Suitable appliances to be used.

(4) Monthly estimates of the work done and payments to be made.

(5) Provision for inquiring into the correctness of the monthly estimates.

(6) Reserving a certain percentage as a repair fund for a stated period after completion.

(7) Conditions of the final estimate.

(8) Engineers' measurements and classifications final and conclusive.

(9) Determination of damages sustained by failure to complete the work within time agreed upon, or as extended.

(10) The discharge of unpaid claims of workmen and material men.

(11) No claims for damages on account of suspension of work.

(12) No claims for damages on account of delay.

(13) No claims on account of unforeseen difficulties.

(14) Protection of finished work.

(15) Protection of lives and property.

(16) Protection against any claims for use of patents.

(17) Assignment of contract.

(18) Contractor not released by sub-contract.

(19) Abandonment of contract.

(20) Cancellation of contract for default of contractor.

(21) Workmen's quarters and other temporary buildings.

(22) Cleaning up after completion.

(23) Removal of condemned material.

(24) Relations to other contractors.

(25) Provision for drainage.

(26) Provision for public traffic.

(27) Contractor to keep foreman or head-workman, also copy of plans and specifications on the ground.

(28) Cost of examination of completed work.

(29) Faults to be corrected at any time before final acceptance.

(30) Surveys, measurements and estimates of quantities not guaranteed to be correct.

31) Contract subject to interpretation and change by the engineer.

(32) Settlement of disputes.

(33) Extra work.

(34) Definition of "Engineer" and "Contractor."

(35) Documents composing the contract.

(36) Meaning understood.

Essential features of good specifications:

(*a*) The work should be described first as a whole, and then in detail.

(*b*) Use clear and simple language, easily understood by the contractors who are to bid. Descriptions should refer to the ultimate end to be accomplished rather than to the means and methods employed. It is not wise to specify methods unless a particular one is preferable.

(*c*) The clauses in specifications should be made mutually exclusive; no part of the work should be described in more than one place. Repetition of descriptions tends to weaken the document.

(*d*) Specifications should be clear in the matter of indicating what is absolutely required without any alternative, and what is named as indicating in general the character of the product, and in which alternative materials, methods or results will be allowed. The intention of the engineer should be revealed in the specifications; the contractor should know in advance how the specifications are to be interpreted, so far as it is possible to give this information in the specifications themselves.

(*e*) The engineer should be familiar with all details of the work described, so as to decide on various contingencies that may arise. This requires considerable experience on the part of the engineer who writes the specifications, that his foresight in this particular may be complete and distinct.

(*f*) Choose units of measure that shall admit of no double meaning.

(*g*) The engineer should be familiar with the ordinary methods employed by different kinds of mechanics and should design his work accordingly. It is difficult to get mechanics to vary their ordinary practice; the failure to recognize this fact often leads to the violation of the contract or the abandonment of the strict interpretation of the specifications by the engineer.

(*h*) Don't specify the very highest and best materials the market affords; it is cheaper to use materials with a minimum limit fairly below the generally recognized first-class grade. The engineer will thus usually obtain a material practically as good as the market affords without having to pay an extravagant price for it, and not be subjected to the delays and troubles caused by the rejection of a large proportion of the material furnished.

(*i*) It is best to avoid specifying a particular manufactured product or proprietary article by name; if this is done at all, more than one name should be given.

(*j*) It is not uncommon to specify that the materials furnished shall be of well-known brands; it is also sometimes specified that the contractor himself must show a familiarity with the work he proposes to perform.

(*k*) The engineer should have a clearly defined notion as to the amount of responsibility to be placed on the contractor; the former should be responsible for faults in his own design, materials and methods of execution. Only in hazardous or experimental work, having no well-defined plan, should the contractor be responsible, and should be left comparatively free, both as to plan and execution.

(*l*) The specifications should be rigidly enforced, instead of accepting other materials or methods "just as good." Don't discriminate against other bidders in favor of the lowest, who, probably, presumed to use cheap methods and materials. If a cheaper compliance is allowed, a corresponding reduction in price should be insisted upon.

The above are some of the numerous controlling ideas which the engineer should have clearly in mind in the writing of a set of engineering specifications. He must know in the first place exactly what he wants, and then to so describe it that others cannot mistake his meaning. The general and detail plans are usually made before the specifications are written, and the engineer has these before him in writing the specifications, and makes liberal reference to them. Since they are also a part of the specifications, he has the advantage of a double language in which to present his ideas, and if he does not succeed in making clear to the proposed contractors exactly what is to be done, he should feel that he alone is to blame for any misunderstanding.

DISCUSSION.

Mr. Meserole.

Mr. W. M. Meserole.—I think a good many of us can remember when we were not drawing our own specifications. We had then to find out what those specifications meant. My first work was on the West Shore Railroad and the specifications used on that work were published as examples of up-to-date practice, but unless they have been materially amended from what they were when used on the actual work, I do not think they are models to be recommended. The masonry specifications were especially rank in the minor classes of which such large quantities are built, scattered along the line of the road and entirely under the supervision of the youngest and most inexperienced engineers. They are classified somewhat as follows:

First class; used in abutments and piers of large bridges and in similar important structures.

Second class; used in ordinary highway crossings where the railroad passes over highways on girders.

Third class; rubble masonry used in box culverts, in the abutments of highway bridges passing over the road, and in retaining walls.

Fourth class; dry retaining-wall masonry.

When the specifications called for third-class masonry, the engineer could get little idea from the specifications except that good work was called for, therefore all he could do was to fight for the best he could get. Almost any stone that was brought on the job the contractor could claim was fit to go into the work without much dressing. The resident engineer could not help the assistant engineer out much because of the indefiniteness of the specifications. Now, I think, to draw up such specifications as that is a confession of great weakness on the part of the engineer, and the engineer who cannot specify exactly what he wants had better get somebody to draw the specifications for him.

Then the question of measurements has been spoken of. The engineer wants to be very particular in stating in his contract and specifications what his units of measurements are. The perch of stonework has about as many different meanings as there are States in the United States. I think it runs down as low as 8 cu. ft. in some localities, and how far upwards I couldn't begin to say. Then when he gets into cut-stone masonry and into house work, generally, he has got to know all about it.

Now the last speaker started out with thirty-seven subjects that should be considered in making up specifications. I think it is the experience of most of the engineers who have to make specifications that they usually put it off until the last minute, and then, if they do not have a good set of specifications to refer to, one or more of the

thirty-seven subjects mentioned will be apt to escape their memory, and they thereby get into trouble or make trouble for others. Mr. Meserole.

Now, it seems to me, that this Club, with such a membership, could do some good work for its members. If those who have good specifications that they have worked under were to turn them over to the Library Committee, with notes showing wherein they were especially weak or otherwise, I think that Committee would undertake to have them properly codified, so that they would be of service to every member who had occasion to draw up specifications. I have no doubt the Board of Directors would see that the expense of classifying and codifying such matter would be met. I think that this is a matter that the Club might take up at some future time.

Now, in specifications, it has very often been stated, and once this evening, that all disputes, all questions of measurements, all questions of workmanship, disputes as to the character of the work and material, and all that sort of thing shall be left to the engineer; that his judgment shall be final, and from which there shall be no appeal. I think that is not a good plan. I do not believe that any man has a right to set himself up in any business transaction as a final arbiter, without the consent of both parties. The engineer is ordinarily employed, or retained in some way by the purchasing end of the business. It seems to me that the fair way is to provide for an arbitration. I never worked on but one job where we had arbitration specifically provided for, and in that job the president of the construction company and the president of the railroad company used to get together every week and modify the contract, which would have made any attempt to unwind the tangle in that case a first-class Chinese puzzle. But, it does seem to me that the contractor should have some standing in the settlement of disputes, and that arbitration should be provided for on matters that are of sufficient importance to call for such action.

It has been stated here that an engineer should be careful not to determine in the specifications exactly what method should be followed in the proposed method of construction. I think that is a recommendation that should be considered carefully before being followed. I think in many cases the engineer is able—if he isn't, he ought to be—to state beforehand the method that will bring about the exact results he desires to obtain in the work, and that he should be sufficiently sure of himself to actually state them in such a way that there would be no question about it (if one method is so much better in his opinion than the others, so that he sees fit to rule out the others) and then to live right up to that. Of course, there are sometimes a great many ways of bringing about the desired result. In such cases I hold that the engineer should be very careful to state exactly what results are to be obtained, and leave out the methods entirely.

Mr. Meserole. Now, something was said about the first and second parties to the contract, that the first party was the party who paid, and the second party, the man who did the work. It has always seemed to me that the man who was to do the first act should be the party of the first part, and the man who was to do the second act the party of the second part. The first act is to provide material, to provide the labor, and to turn over a finished job. Then the second party comes up and receives it. The buyer should then be the second party.

I would like, if this discussion can take that direction at some time during the evening, to hear some opinions of the engineers present on the advisability of engineers in calling for bids for work which would call for a design to be furnished as a part of the bid, as in bridge work for instance, or whether it is considered that the engineer should furnish all designs. That is, whether or not the contracting company desiring to have the work done should furnish the design, and that bidders should all bid on one design. That is a matter that has received a good deal of discussion outside the profession, very often to the detriment of engineers, and I would like to hear what the men of the profession think about it.

It has been said this evening that the results should be very clearly described in the specifications. For certain kinds of work this can be done. In the case of the finer kinds of stone cutting, however, I don't think you can put the result in writing. The Aqueduct Commission kept standard samples for such work in their offices and referred to those samples in their specifications; and they recognized, also, that dry masonry cannot well be described in specifications. It seems to me that there are quite a number of things that cannot be properly described in writing.

Mr. Granger. Mr. A. B. Granger.—It seems to me the idea of this general specification scheme is to avoid trouble which has occurred in a good deal of city work, both here and in New York. For instance there has just been drawn up a general specification on very important work which did not specifically call for a fixed design. The contractors are asked to submit their own designs and detailed specifications.

This subject has been discussed a great deal, and I do not see why, with all the engineering force that the municipalities have, they couldn't go into this thing in detail, and get up a plan on which contractors could bid.

Then, there is another point which I would like to bring out, that is the importance of having the terms of payment specified in the specifications, so that the contractor could know when he is looking at it whether he wants to bid or not. The question of finance in large contracts is an important one, and the contractor doing his work all on his own financiering has got to consider the question of the time that this contract is to run, and the terms of payment he is going to

get on it. He has got to figure on the question of inspection, and a good many things that affect his bid very materially. Mr. Granger.

Mr. N. P. Lewis.—There are one or two things that I want to say concerning lump-sum bids versus itemized bids. I have been surprised on several occasions to hear the advocacy of lump-sum bidding on the ground that the contractor is almost certain to overlook some of the items, and that the purchaser is likely to get the benefit of it. That is a piece of sharp practice, which I think is unworthy of the purchaser, if he is a man, a corporation, or an institution of any character. Now, I believe that it is only just that every particular item of work of different classes should be bid for separately, so that there can be no misunderstanding whatever as to what work the contractor has to do. It may cost a trifle more in the end, but you have the consciousness of doing absolute justice. It very frequently happens, however, that it is utterly impossible to foresee every contingency which may arise, and to provide for all the work which is necessary to be done to carry out the improvements in a satisfactory manner. Under contracts let by private companies, or individuals, this is a simple matter. In municipal work, however, it is a very difficult thing, especially if the work is to be paid for by an assessment upon the property benefited. It is almost impossible to make a supplemental contract for extra work without running the risk of invalidating the assessment, for you cannot show the people who have to pay for it that they have had the benefit of competition in this one item. Mr. Lewis.

Frequently contracts are authorized by legislative bodies, which attempt to describe them minutely, instead of providing for the improvement in a general way, and then allowing the administrative officer, or the engineer, to carry out the work in a suitable and proper way.

The actual drawing of the specification and soliciting of the bids may take place a year or more after the improvement has been authorized, and you find yourself tied down by the authority which was given you, which attempts to specify items, but has omitted something essential which you are obliged to have done and to provide that the price must be included in some other item. This is unsatisfactory and, in my judgment, unjust.

The system of unbalanced bidding is a very troublesome one. There seem to be contractors so constituted that it is utterly impossible for them to put in a straight and frank bid, with a reasonable price for each item. The specifications which have been used for years by the City of New York present a curious anomaly. On one of the first pages it is distinctly stated that no bid which does not name a sufficient and reasonable price for every item will be considered. Yet this same contract devotes half a page in laboriously providing that where partial estimates are given, and an unreasonable price may be named

Mr. Lewis. for any particular item, the amount to be paid shall not be determined by the amount of work of that class which has been done multiplied by this unreasonable price, but that only the fair value of the whole amount of work done shall be allowed. Such curious inconsistencies have been perpetrated year after year.

Now, while I believe in making a contract or specification just as clear and explicit as possible, there is such a thing as excess of detail. It is about as serious a thing to say too much in describing work of any class as it is not to say enough, and my attention has recently been called to several specifications which go into such details in a very absurd manner. For instance, a recent specification in describing the making of concrete for the foundation of a street pavement, described at great length that the stone should be brought on the ground in proportions of 2 parts of a certain sized stone, very specifically described, to 1 of another part of stone described with equal exactness, and that they should be placed in separate piles. The cement and sand should be mixed on a platform of given dimensions, after which the center of the platform should be scraped clean, and the mixture made in a ring of uniform section and a certain diameter. One-third of the pile of the larger sized stone, after having been wet and drained, should be placed inside of the ring, and to this should be added one-third of the pile of smaller sized stone. Over this stone should then be sprinkled one-third of the surrounding dry mixture of sand and cement. On this dry layer shall then be scattered one-half of the remainder of each pile of stone having been wet and drained as before, and this layer shall be sprinkled with water. One-half of the remaining dry mixture shall then be spread, followed by the remaining one-third of each pile of stone, drenched, drained and sprinkled as before. Then the remainder of the dry mixture shall be added and the entire mass shall be turned over until the broken stone is thoroughly mixed and completely incorporated with the mortar.

Now, this, of course, is ridiculous, and it is one of those instances of excessive detail which are just as bad as vagueness.

As to contract time, which is always made a part of the specification, it is usual to fix a limit within which the work must be completed, and provide a penalty for any excess of this time. It has always been troublesome in framing a contract to so word such a paragraph that this penalty could be legally imposed unless a bonus is offered to the contractor for completion in less than the contract time. Here, again, municipal work is at a great disadvantage. A private corporation can always give a bonus for completion within the contract time. This, however, cannot be done on municipal work if any assessment has to be laid for it. By doing so you would be increasing an assessment in a way which you cannot satisfactorily explain, and which the property owners could successfully contest. It is very hard

to prove actual damage for excess of time, and I do not believe that, unless you are in a position to give a bonus, the penalty for excess of time should be as severe as it frequently is made in contracts. The ordinances of the City of Brooklyn formerly provided that the penalty for excess of time over that named in the contract should be $5 a day on all work costing $5 000 or less, with $5 a day added for each additional $1 000. This would amount to $480 a day on a $100 000 contract. Mr. Lewis.

The desire on the part of the contractor to furnish something just as good as the contract calls for, but a little different, seems to be inherent. I know perfectly well that if you give a contractor the choice of five, six, seven or ten brands of cement, anyone of which he can use, that one-half the contractors will come to you with the statement that they have something else that is just as good. They seem to have a strong aversion to being tied down to even one of ten brands.

I believe that the engineer occupies something of a judicial position, and that he should endeavor to do absolute justice to the contractor, as well as justice to the party that employs him, and I think that Mr. Cranford's views on this subject, which are from the contractor's standpoint, are perfectly fair and reasonable.

Mr. H. B. Seaman.—If no one else wants to speak, there are one or two points mentioned by the last speaker that I would like to refer to. With regard to the question of penalty, it might be well to know that a penalty can never be enforced. Engineers do not always understand that, but a penalty cannot be enforced in law, no matter how often you put it in your contract. Mr. Seaman.

As to the first party being the man who does the work, and the second party being the man who pays for it, is not the first party the man who seeks to have the work done? Without his initiative we never would have the work done, and that is the reason he is put in as the first party. It is not an engineering function, but a legal function; that is, the first party pays the bill.

As to the question of the engineer being the arbiter, I think that is the only position that any engineer should ever take. I think no engineer has any business to be employed by any man for the purpose of using his profession to get the best of somebody else. We should describe as nearly as we can what is wanted, and then interpret it fairly, in justice to all parties. I think any engineer who does more than that is unfair to himself.

The question has been mentioned as to the advisability, or the equity rather, of asking for plans with bids. I think that engineers should make the plans, and that contractors should not be asked to submit plans with bids. Let the contractors come forward and say: "You get an engineer to make your plans and we will bid on them."

Mr. Seaman. The most extreme case that has ever come to my notice was a request for bids with plans of a large bridge at Quebec. I suppose that was a structure costing somewhere between $1 000 000 and $3 000 000, and the parties asking for bids had no other purpose than to get an estimate of the cost, in order that they could use it as a basis on which to capitalize the scheme.

Mr. Duryea. Mr. EDWIN DURYEA, Jr.—There is a method of calling for bids which is not, I think, unjust to the contractors. That is, where the engineers make full plans and, in calling for bids, allow the contractors to bid, not only on those plans, but, also, on plans made by themselves. This was done in the new East River Bridge caisson work. The contractors had the privilege of making their own plans, and if they thought they could design cheaper caissons than ours they were allowed to make bids on their own plans in addition to ours. Their plans, however, would be subject to the acceptance of the chief engineer, and would not be accepted, of course, unless they were considered as good as ours. That plan cannot be considered unjust, as all contractors had the same basis on which to bid, and the chance to use their own knowledge at the same time.

Mr. Colby. Mr. S. K. COLBY.—Just one or two more remarks. As to special cases not being sufficient in detail, or rather being too verbose, there are one or two instances I want to mention from the other side. There was an instance that came under my notice of the construction of a certain section of railroad. It wasn't a very large section, but the amount of excavation was considerable, and when the specifications were drawn, the country in the neighborhood, on the face of it, and so far as the oldest inhabitant knew, consisted mainly of a formation of clay, and then solid rock. After the contractor got down quite a little distance he found a peculiar conglomerate that couldn't well be classed under either head. It wasn't earth, because he couldn't get it out with any earth-handling apparatus; and it wasn't rock because it didn't require blasting. The question then came up as to the engineer being the judge in the case, and the engineer went so far as to admit that the specifications were incomplete, and established a third classification: That all material which could be handled with a six-horse plough would come under the head of earth; and that material not earth or rock would come under a medium classification on which a price was stated.

There is another case I have in mind that is very peculiar indeed, so far as the reading of the specifications goes. The United States Government, in one of its departments particularly, very often gets out what they call "open requisitions," on which the specifications are very broad. In the specifications for certain building work, which are written at some length, there is a final clause which reads: "Any other work necessary to the completion of this work that in the opinion of

the engineer may be necessary," etc. Now, a liberal reading of that clause would simply mean that the engineer who had it in for the contractor could make him put feathers with a mucilage background on everything. Of course, that seldom occurs, but the clause is there, and it is seemingly very peculiar. Mr. Colby.

The question of the unbalanced bid that was brought up here has one phase which appeals to some contractors, particularly contractors with limited means, that wasn't mentioned, that is, in a large piece of work that requires considerable money to finance it, depending upon the way the payments are to be made. If they are to be made in periods, irrespective of estimates as sometimes occurs, my remarks do not apply. But in case they are under the engineer's estimate of the work, as, for instance, suppose a certain contract including considerable excavation is to be done. The first estimate would, naturally, be for the amount of earth taken out. Many contractors acting, I think, in perfect good faith and wanting as much money as they can get on the first one or two payments, in order to enable them to go ahead with the rest of the work, might here utilize an unbalanced bid. There would be no loss to the corporation, so far as I can see, if he puts in earth excavation at larger figures than actual cost in order to get his finances straightened out. Now, it may be an open question as to whether that is really legitimate under the strict reading of the specifications, but it certainly is an advantage to the contractor; and, so far as I can see, of no great disadvantage to the municipality, or parties requiring the work to be done.

Mr. R. L. Williams.—As to the engineer always furnishing the design and plan, the contractor would sometimes prefer to furnish his own on account of having his own patterns and material. Mr. Williams.

In one case I can recall the requirements were for bridges of certain spans, from 30 to, say, 100 ft. (this would not apply to larger bridges), and they were required to support so many tons weight, so much rolling load, etc. The large bridge companies would bid on those requirements.

If the bid was accepted they would furnish their own plans, subject to the approval of the engineer going over them. In that case each bridge company preferred to furnish its own plan.

I have listened to the discussion to-night on specifications with a great deal of interest, hoping to hear one thing that has always struck me—that is, I would like to have some one get up a specification which on grading work would make the contractor preserve his stakes.

Mr. J. C. Meem.—I knew one specification which classified hardpan as material which could not be ploughed with less than six mules. The contractor always hitched up these six mules when the engineer came in sight; when the engineer was out of sight he usually ploughed with two. Mr. Meem.

Mr. Meem. I think the chief point in a specification is to formulate something which can be carried out, and if a specification isn't carried out and cannot be carried out, there is something wrong somewhere.

I have heard it stated in this city by prominent engineers—engineers well up in their profession—that it is useless to draw up certain clauses in specifications, because they could not be carried out as contractors were used to their own methods of working and would not change. I think that specifications should be reasonably simple and then lived up to, even if we have to educate some contractors.

One of the most amusing incidents I ever heard of regarding the theory and practice of specifications was related by Mr. Wright, of the Edgemoor Bridge Works, Wilmington, Del.

He observed a laborer engaged in making a most fearful and wonderful mixture of concrete, and finally asked if the engineer allowed him to mix his concrete that way. "Why," said the man, "he is the most careful engineer you ever saw—every barrel of this cement has been tested and the engineer is now at the office testing some more."

Mr. Tillson. Mr. Geo. W. Tillson.—I think that, generally speaking, plans and specifications are for two purposes. The first one is to tell the contractor what he is expected to do, how much and what; and, then, how he is to do it. The fewest words you can put that into, the better. You don't want too few, because you don't want anything left out that should be in; nor too much, so as to allow for misunderstandings. But, as has been said here to-night, they should specify exactly what is to be done in detail. Don't attempt to hide anything from the contractor, or fix it in such a way that he is liable to forget anything; because I do not believe that any public corporation, any city or municipality, wants a contractor to do work for nothing. I do not think he ought to be expected to, and I do not think any private corporation, or individual ought to want them to work for nothing.

Now one illustration, and I think the best I ever saw, that came under my own particular notice, of putting too much in the specifications, was in a western city. At that time I was in sympathy with Mr. Cranford, as I was representing the contractor. It was a sewer contract, and in their notice to bidders, and in the part of the contract where it referred to prices, it said that the price should include all the necessary shoring, preparation and protection in going under all railroad tracks. In a subsequent paragraph there was a clause similar to this: "In passing under the tracks of any railroad the contractor shall allow the railroad company every facility for protecting its track."

This was evidently in conflict with the preceding, and when a test case arose the city paid one-half of the extra cost of passing under the tracks.

Another gentleman has spoken of a case where the specifications

Mr. Tillson.

were indefinite. I had a case of that kind, too, come up in my experience, when I was on the contractor's side. That was down south, where they were advertising for a system of sewerage for the entire city. The bids, to show the size of the work, varied from $100 000 to $175 000. The work was divided into five districts, I think, and bids were received separately, or as a whole, on all the districts. They might make five contracts, or they might make one. I figured on four districts, and coming to the fifth found no plans, no profiles, nothing to tell the depth of the sewer. I said to the engineer: "What are we going down here in District 5 for, there are no profiles." "Well," he said, "You will have to go down there and look over the ground, and decide yourself how deep they will have to be." I went down to District 5, and found that it was a swamp. About half of it was covered with water, and contractors bidding on it were expected to do so without having any plans or profiles on that part of the work. The man who finally got the contract, however, did not carry it out.

Another gentleman has alluded to a large piece of work where there were no plans or specifications provided. I think he also has heard of one larger when he calls it to mind, and that is the case of Havana. It is an actual fact that the City of Havana, when advertising for paving and sewerage work, asked the contractors to furnish their own plans and specifications on a job amounting to $12 000 000 or $15 000 000. The bid furnished by Mr. Dady was actually accepted by the city officials of Havana, formally and legally, and, I suppose, he would have carried out the contract had it not been for the Spanish War.

There is another point in specifications that is rather a vexed one, and I don't know how it could be exactly settled. That is where you call for a guarantee that the structure, of whatever nature it may be, must be guaranteed for a certain period. Now, when you make detailed specifications it is, I think, an open question at least whether you have a right to tell the contractor just how he shall do that work, if he must keep it in repair and make it good for 5, 10, 15 or 20 years; whatever the case may be. He, of course, will say he has guaranteed it, and he wants to do it his way. I think he has a good deal of justice with him in that case.

I believe that in any specifications where it is required that the work shall be guaranteed for an extraordinary period—by that I mean the period beyond which it is expected to show anything that is wrong in the work itself or in the material—that they should be general, rather than definite and specific. Asphalt pavement when it was first laid was required to be guaranteed for a certain period of years, because it was uncertain what kind of pavement you would have at the end of five years. During the first ten or twelve years that asphalt pavement was laid, the specifications were made up by the contractor, and rightly so, because contractors knew more about it than any engineer did.

Mr. Tillson. I would say, in justice to the cities, that contractors do not always get the best of them, as shown by this instance. The specifications on some sewer work required that no sheeting should be paid for unless ordered in writing by the Board of Public Works. Quite a quantity, however, was left in on the verbal order of the engineer, and the inspector took an account of it and reported it to the Board. The Board never would pay for it, and when a suit did arise from all of the misunderstandings on the contract, and the case was tried, the judge decided that the city was not liable for that sheeting that was ordered left in by the engineer, and reported by the inspector, because the contractor did not have a written order from the Board of Public Works. This shows that the contractor in a great many cases should be as careful in having specifications carried out as the engineer is.

Then, especially in sewer work, there is always a question as to how much detail should be shown in the specification. That is, whether it is necessary to show whether there is water or water to be expected, or whether there is rock or rock to be expected. Now I believe that if you attempt to show any of these you must show them all. That is, if you say in your plans that the trench shall be kept free from water without charge, and then you show on half of your plan that water is expected, and if you find it on the entire work, I believe that the city is liable for the part that you do not show. For that reason I believe it is proper and safe for the city to specify that the contractor must make examinations himself and satisfy himself whether he will or will not find water or rock in any part of the work.

Then, in line of what has been said here before, I think that the engineer in preparing specifications should be particularly careful to put in nothing, except what he can enforce. That is, have the contractor understand that it should not be necessary to educate him (I don't see any objection to that word), but have the contractor understand that you take it as a matter of course that, if it is in the specifications, it must be lived up to. Now, a man appreciates that if he has been traveling around the country superintending work in a great many sections.

And then there is the unbalanced bid that is always liable to make a good deal of trouble. If you specify that a portion of the work may be of brick, part may be of stone, or, if it is gutter, that part of it may be of stone or it may be of brick, granite or cobble, and after the contract is awarded the quantities are changed, the contractor may be the highest bidder rather than the lowest.

The classification of material, I suppose, is really a harder question to solve than almost anything else. What is rock and what is earth, or what is loose or solid rock, is capable of a great many interpretations. I suppose on the Chicago canal there was more trouble of this kind than on almost any work that has been carried on in this country.

They had a classification there that they called glacial drift that was a sort of hard close compact gravel that was as hard to get out about as solid rock. But it was classified in the specification as glacial drift, and it was held up to that, and a great many contractors failed on account of the specifications being adhered to rigidly. Mr. Tillson.

I remember in reading the report of the engineers on the canal investigations a year ago, recommendations by the experts on classification to classify as rock anything that could be removed by blasting more profitably than by any other way. Now, that, of course, is all right in certain materials, but where it comes down to a pretty close definition one contractor might, by his better understanding of how to use blasting materials, make it more profitable to blast where another man could take it out more easily with a plow. So this, I think, is the most difficult problem to settle in the classification itself, and the hardest to determine before the work is carried out.

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RECENT DEVELOPMENTS IN THE MANUFACTURE AND USES OF ALUMINUM.

By Safford K. Colby, M. B. E. C.

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The history of the discovery of aluminum and its subsequent development is interesting, but I will pass over this early work very briefly and will attempt to give you something of our present knowledge of this interesting element.

Somewhere about 1807, Wöhler, with the aid of metallic potassium, performed experiments in the laboratory, which demonstrated that this metal could be isolated; but these experiments were of no commercial value at that time. From then until 1854 the metal was not produced in any way on a commercial basis. In 1854 the first attempt was made with what has since become the cheapest method of production, viz., the electric current. Of course, the dynamo was a thing of the future, and simple batteries were used for the electric current. A solution of the double chloride of aluminum and sodium was used, but the results were not commercially of value. Owing to the fact that the compounds of aluminum are widely distributed over the earth, very early in its history great claims were made for the future of the metal. It was going to be cheaper than, and replace, iron; in fact an aluminum age was to follow the iron age. These extravagant claims

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were shortly disproved, however, first because of the impurity of the early commercial metal as then manufactured; and, secondly, the difficulty in dissociating the metal from its salts, particularly with the facilities that the older chemists had.

You can judge somewhat of the rarity of the metal from the fact that in 1855 the value, impure as was the product, was $90 a pound. In 1857 the value had been reduced to $32 a pound, owing to the use of the metalloid sodium for its reduction, and in 1887 the cost was reduced to $12 a pound through the reduction in the price of sodium, due to improvements made in its manufacture by Mr. H. Y. Castner.

In 1886, Charles M. Hall, in this country, and Mr. Pierre Heroult, in England, at almost the same time, took out patents covering the production of aluminum by means of the electric current, although the process of each was radically different. The first attempt to develop either of these methods in this country was made by Cowles Brothers, of Cleveland, Ohio, who started a reduction works, acquiring the Heroult patents. These patents covered practically an electrolytic furnace; simply a long pot with carbon linings and carbon electrodes projecting inward from the end. A current passing between these carbons gave a very high heat, and within the influence of the arc the ore was placed. The heat was sufficient to separate the metal aluminum from its oxide, but it was impossible to hold it outside the direct heat of the arc, and it would immediately return to the form of the oxide. To avoid this there was placed below the arc some other metal of higher melting point, such as copper or iron. Their patent then consisted in reducing aluminum in the presence of iron or copper, which gave a very rich alloy, ranging from 15 to 35% of contained aluminum.

It has been found impossible to separate copper and iron alloyed with aluminum, from the aluminum itself, and consequently the value of this process was confined to the production of alloys of aluminum only.

Charles M. Hall first conceived and patented the idea of the production of the metal by the use of true electrolysis, and was employed by the Cowles Company at one time to perfect experiments that he was trying to carry through. They did not believe, however, that the scheme that he proposed was satisfactory, and, in consequence, did not give him the backing that was necessary. He left them and

went to Pittsburgh and formed there a company backed by Pittsburgh capitalists. His patents were purchased and the metal put on the market. Meanwhile, in Europe, Heroult and Mr. E. Kleiner had taken out patents covering practically the ground of the Hall patent. In an attempt to take out an American patent, however, Hall was given a priority in time and Heroult withdrew.

The patents covering the reduction, according to the Heroult and Kleiner process, were bought by the Aluminum Industrie Actien Gesellschaft, who operated at the Falls on the Rhine in Germany. After first using Heroult's original scheme, they finally adopted the latter method, which was practically similar to the one that Mr. Hall patented in this country. A little later than this, the French also took this question up, and bought from the Pittsburgh Reduction Company, the owners of the Hall process, the French rights for the manufacture of the metal. They termed themselves the Société Industrielle de l'Aluminium and their works were at Froges and La Paz.

As soon as the Pittsburgh Reduction Company had developed the process sufficiently to put the metal on the market, producing at that time some 200 to 300 lbs. a day with their small facilities, the Cowles Company attempted immediately to operate under the same patents, as, of course, the process was well known to them. A suit was started and an injunction asked by the Pittsburgh Reduction Company, claiming infringement, and, after a bitter fight, this suit was decided in favor of the Pittsburgh Company. From that time the production of aluminum in this country has been steadily enlarged by this Company.

Taking up the method of production in detail as now practiced, the first question of importance is the original ore. The ore that has up to the present time been found most suitable is the unpurified oxide known as bauxite, which is found in the States of Georgia, Alabama and also in Arkansas. This ore is one of the simplest conditions in which the oxide is found. It is not a clay. Clay contains much alumina, but it is largely composed of silica, or compounds of aluminum and silicon in varying proportions. The presence of silicon in the ore is very objectionable, and, consequently, an ore must be used which is as free from silica as possible and good bauxite, for the production of aluminum, contains less than 3% of silica, with small proportions of iron and titanic acid.

Bauxite is usually found on the surface of the ground and its mining is very simple. The material can be delivered in Pittsburgh for \$8 to \$10 a ton. The cost now is somewhat less than this, but it depends very largely on the freight rates. Bauxite, as it is mined, looks somewhat like clay, and the color varies from a pure cream to a reddish brown tinge, which red is due to the small percentage of the oxide of iron present. Its average composition is 59.7 to 62% of Al_2O_3 and 32 to 35% water.

This is a piece of bauxite (exhibits sample), and the characteristic surface of the fracture is plainly seen. Its appearance somewhat resembles the surface of a gravel bank, or technically, it has an oolitic structure. The material is taken in that impure state and calcined with sodium carbonate. At the present time the Pittsburgh Reduction Company do not do this burning themselves. It is one of the economies that may be introduced in the future. The material is shipped to the Pennsylvania Salt Works or to the Solvay Process Company in Syracuse, who have large works which are suitable for that purpose. After the material is burned with soda ash, the principal resulting compound is sodium aluminate. The temperature of this burning must be kept below the melting point of sodium aluminate, or silicate of aluminum is formed, which, of course, is not desirable. The burned mass is taken from the furnace, ground and lixiated with hot water. The sodium aluminate is soluble, leaving a large proportion of the silica and iron as a solid residue. The aluminate in this purified state is precipitated from the solution by carbonic acid gas. This gas is simply forced through the liquid, and sodium carbonate is again formed, in that way making the process continuous, as the reformed carbonate may be used again. The pure aluminum oxide, the hydrated oxide, is deposited in the form of a flocculent precipitate that is semi-transparent. This precipitate is dried and then pressed, and finally takes the form of a white powder. The water of crystallization retained in this hydrated oxide amounts to some 40 odd per cent. by weight, and, of course, must be driven off by again heating.

The Pittsburgh Reduction Company have their own calcining furnace for this material, and the only difference between the calcined and the uncalcined material is simply in the fineness of the grain and its weight. The material is then taken to the electrolytic furnace.

The electrolytic plant of the Pittsburgh Reduction Company has been moved from Pittsburgh to Niagara Falls, where, of course, water power is far cheaper than coal power would be, even in the neighborhood of Pittsburgh. This move was also found desirable because it was found impossible to get a steady enough current to reduce aluminum, at the same time to produce power for rolling mills, wire drawing apparatus, etc., without two entirely distinct power plants.

In producing alumina, the question has been raised several times as to whether there was not some cheaper process of production than the one that I have outlined. Some experimenters have endeavored to carry it out by the use of sulphuric acid and some of the ores of aluminum that are very rich in oxide, such as sulphides or sulphates. That is possible and has been done, but it is found to be in the end more costly. There is an opportunity for improvement, which, if it does come, will probably cheapen the production of the metal to some extent.

As an ore for the production of alum, used so extensively as a mordant for dye work, it has a large field. In this it need not be so pure.

The preparation of this anhydrous alumina is the first set of complete operations in the metallurgy of aluminum. In the second lies the value of the Hall patent. The patent consists in the discovery that the mineral cryolite, a double fluoride of aluminum and sodium, when melted, has the property of dissolving anhydrous oxide of aluminum, and Hall's process consisted in heating this material to its melting point, adding the aluminum oxide, and subjecting the bath to the influence of a powerful electric current. In the words of the patent, the general statement is that it consists in "dissolving alumina in a molten bath of the fluoride of aluminum and the fluoride of some more electro-positive metal." The electro-positive metal may be calcium, sodium or potassium. As a matter of fact, the mineral calcium fluoride is by far the least expensive. The natural cryolite, with which the first experiments were made, comes from Greenland. There are no deposits of any size in this country.

Commercially, in this process, oblong pots are used, about 5 ft. x 4 ft. and about 3 ft. deep. These pots are of ordinary sheet iron, and are lined on the inside with 2 to 4 ins. of ground carbon dust, with just sufficient cementing material to hold it together. In order to

pass the current through these pots, they are first filled, or partly filled, with ground cryolite. Because of the great cost of cryolite, a cheaper electrolyte is used, which, while it is made artificially, fulfils the necessary requirements, as stated above. In other words, the manufacturers go Nature one better and make a cheaper product, which will answer the same purpose. The electric current is passed through many large carbon anodes about 3 ins. in diameter and about 20 ins. long. A copper rod is run down into the middle of each carbon anode and is attached to the heavy conductors that carry the current. The carbon anode then acts as the positive pole, and the electrolyte itself, together with the carbon lining on the bottom and sides of the pot, acts as the negative pole of the furnace. When this cryolite, or its substitute, is put into the pot and the current is turned on, the heat generated is soon sufficient to melt it, as the melting point is not very high. Then a surface covering of carbon dust, about 3 ins. deep, is placed on top and the alumina on top of that. The workmen go from pot to pot with copper rods and stir in this alumina, tapping the metallic aluminum off from time to time from the bottom of the pots. From a chemical standpoint, experts differ materially as to the action that takes place. Whether there is some complex double fluoride formed, and that dissociated, or whether the bath acts as a passive agent, is a question not fully determined. The fact is that while the bath retains a constant volume, less losses due only to handling, the alumina is separated into oxygen, which goes off as CO or CO_2 at the positive pole, and the metal, which constantly deposits at the bottom and sides of the pot. The important and interesting fact is here called to your attention, that there is a loss of less than one-half of 1% of the aluminum contained in the original ore during the entire process of its production, and that the two main reactions are reproductive, *i. e.*, the principal materials are used over again. If the pots run dry the electrolyte itself will be decomposed, and the noxious fumes of fluorine, or some vaporous compound of fluorine, are thrown off into the air. Thirty per cent. of alumina will make about a charge for each pot. The first run of the pots contains considerable iron and silica, and the metal produced is of no value commercially, except as a separate product, and of its use mention will be made further on.

This gives you in outline the process for the production of the metal. It is run off into large pigs and shipped back to Pittsburgh,

where the rolling mills turn it into the form of wire, rod, sheet and tubing.

Impurities are reduced to a minimum. The contained iron has been reduced to such a point that it is less than .01 of 1 per cent. Silica will range anywhere from .04 or .05 up to .0.3 of 1 per cent. The pots sometimes give a very uniform product, and at other times they will not, and the only thing to be done with the impure product is, of course, to use it for some purpose where purity is not necessary. There are also slight impurities not as easily determined. Carbon and sodium, and sometimes copper, will get into the metal, and it is only with the greatest care that a pure metal can be produced. Much of the complaint and reported failure of aluminum to weather, under certain conditions, is due to the impurities that the metal may have contained. While it has been cheapening, the percentage of impurity has decreased and will continue to decrease as more and more refined methods are introduced.

Several other processes could be given for the production of aluminum, but, as stated before, all the commercial processes have reduced themselves to the one system described, with or without modification. The possibility for the discovery of some new process for the manufacture of this metal has been and always will be an interesting field for experimenters. If an analysis of the cost of reduction by the electrolytic method is made, such analysis, though approximate only, will give a fair idea of the actual cost as compared with some other possible method.

2 lbs. alumina (Al_2O_3, containing 54% Al), at 2.5 cents.	$0.05
1 lb. carbon, at 1½ cents	.01½
Electrolyte, carbon dust and pots	.01
20 E. H.-P. one hour, water power	.04½
Labor and superintendence	.02½
General expenses, interest and repairs	.02½
	$0.17

While these figures give definite costs, the limits stated have not yet been reached by any of the producing companies, but with constant cheapening by labor-saving devices and increasing production, such limits are well within the possibilities of the next few years. Examining these items, it is evident that the ore will probably always be the

most expensive item. Cheaper methods of purification and lower freight rates may modify it. It is, however, the simplest ore that can be used and, so far, the most readily purified. Two and one-half cents will cover other materials and plant, or $7\frac{1}{2}$ cents for the ore ready for reduction. Any reduction process depending on heat alone would, in all probability, require a much greater cost for such preparation. The item of power can and will be reduced as newer and cheaper power propositions are put on the market, and this item must be compared with the cost of heat and the greater wear and tear in any process depending on heat alone, where electrolysis is not used, the actual heat in the electrolytic process being comparatively small. The item for labor and general expenses must be about the same for each, with an advantage in favor of the electrolytic method, in that the plant is very simple and the repairs small.

Probably the most likely field lies in the production of other valuable products with aluminum, the metal being in a sense a by-product. Such a process would be of great value, but it must be one that will require the entering of new fields of research, as yet untrodden.

Besides the one concern manufacturing in this country, there is one in Germany on the Falls of the Rhine, one in France (both of these have been already referred to), one in Great Britain, and one prepared to utilize water-power in Norway. All told, their production is not much greater than the one United States company.

Within the last two weeks occurred the death of the man who is primarily responsible for the wonderful strides in what was a new industry but ten years ago. Captain Alfred E. Hunt was the prime mover in the formation of the United States company, and it is largely owing to his efforts that the industry has been placed on the footing that it is to-day. Overcoming all prejudice and working against many obstacles, he directed his efforts toward the cheapening and bettering of the product, so that to-day, instead of being but, at best, a metal for expensive trinkets, it has reached its own field of usefulness, encroaching even on copper and tin.

Taking up the uses of the metal, which are of more interest to you probably than the actual production, this field is constantly broadening. Not only is aluminum replacing other materials, but it is creating new uses for a metal through its peculiar adaptabilities.

Much has been written of its physical and chemical properties, but only those which have to do with its principal commercial uses to-day will be touched upon.

One of the principal properties of the metal, viz., its great affinity for oxygen, is responsible for its extended use as a deoxidizing agent. It can be seen from what has been stated previously that the affinity which the metal has for oxygen is exhibited by no common metal, *i. e.*, no ordinary commercial metal. It is used in the manufacture of steel and steel castings, in the making of certain bronzes, and in zinc baths for galvanizing. The effect in all of these processes is simply to carry off a certain percentage of impurity. Oxygen, in its various oxide forms, really constitutes the majority of these impurities. For instance, take the fabrication of steel. There is no such thing as an aluminum steel. Mr. R. A. Hatfield, of the Institute of British Engineers, has gone very thoroughly into that matter, has written several papers on it, and if an attempt is made to analyze a steel which has been treated with aluminum, there is no aluminum shown in the analysis, simply because the aluminum is burned up, or rather oxidized, and in that it has its true value. Just imagine to yourselves a proportion ranging from 4 to 6 oz. of aluminum to a ton of steel. That is what gives the result, and any more than such a proportion gives results to be avoided, as it increases the shrinkage to a marked degree.

The effect of the metal on low carbon steel is to combine with the oxygen and occluded gases causing the ebullition in steel ingots, and to form a light slag which comes to the surface of the mold. The addition of this small quantity of aluminum, added either in the ladle or, with more economy of the aluminum, in the molds just after pouring, has the effect of quieting the molten steel, but does not necessarily increase the heat of the metal. There are two theories to account for this action. One, as stated before, the affinity of aluminum for oxygen, causing a breaking up in the gases, or that the aluminum greatly increases the solubility in the steel of the gases usually given off at the moment of setting, which usually form blow holes and bubbles. There is no stirring necessary as the aluminum seems to permeate the body of the ingot with great rapidity, once it is forced under the surface of the molten metal. The saving in crop ends alone much more than warrants the cost of the aluminum. With high

carbon steels there does not seem to be the same necessity for the use of a deoxidizer, because there is not this ebullition or boiling in the ingots.

This process for a time was under the disadvantage of certain patent rights which curtailed its extended use. These patents have run out, however, and the process is being used extensively by steel makers and in steel castings particularly.

The same effect is noticeable in the casting of bronze. A very small proportion of aluminum will make the metal flow much better, and will make a relatively poor grade of yellow brass much cleaner and more homogeneous in the finished casting.

The effect of aluminum on an ordinary grade of cast iron is not of such advantage. While it acts as a deoxidizer, and while it has a tendency to soften a hard iron by rendering the combined carbon graphitic, as a matter of fact it is found that the aluminum has a greater tendency to unite first with the silicon in the iron than it has with the carbon. This effect is not at all desirable as it gives the same result as would the casting of a desiliconized iron, *i. e.*, blow holes.

Aluminum does not permeate a mass of iron as it does a mass of steel. The action of a very small proportion of aluminum in cast iron is, however, very noticeable. After pouring the hot iron from a cupola and after the addition of the aluminum, the first effect is to cover the surface of the pot, or the ladle, with a very thin iridescent scum. This scum on analysis shows a large proportion of silicate of aluminum, and, covering the surface, makes the molten metal look cold. Men who have been handling hot iron for years would state at once that such cold metal could not be poured, but on actual pouring it is found to be so hot that in many cases it will cut off the surface of the mold.

There is no particular value in using aluminum in connection with the puddling process for wrought iron. It has been successfully used in the process for the production of so-called wrought-iron castings. This is known as the "*Mitis* process." With the addition of a small amount of aluminum it is possible to actually pour melted wrought-iron scrap which on fracture will show a very much better grade of material than an ordinary casting. The result, however, is not commercially satisfactory. The only concern that ever operated to any great extent in this country has ceased to exist.

Aluminum is also used as a deoxidizer in the galvanizing bath. The effect is again a fluxing or removal of impurities, which gives a greater fluidity and, consequently, a greater surface covering capacity to the spelter. It is invaluable for this purpose, and no concern of any size is without a supply.

Next in importance, if not first, is the question of the electrical conductivity of the metal; its use for electrical purposes. It is only recently that extended experiments have been made in this direction. Of course, it has been realized for some time that if aluminum could be gotten cheap enough, it would to a certain extent replace copper. Just at the present time with copper at prices ranging from 18 to 19½ cents per pound, where it was 13 and 14 cents or even lower a year or a year and a half ago, the difference in weight between aluminum and copper, even with the 40% difference in conductivity, shows a material advantage in favor of aluminum conductors.

The conductivity of aluminum is only 63% of the conductivity of copper as a maximum. Commercially, 60 to 62% can be very readily obtained. The weight of aluminum compares with that of copper as 1 is to 3.3. To put this in a slightly different way, 1 ft. of copper wire of a certain diameter will be equivalent in weight to 3.3 ft. of aluminum of the same diameter. The combination of these two properties of weight and conductivity give aluminum an advantage over copper at present prices.

With copper at 18 cents per pound, it is now practicable to produce aluminum to compete with it. Even were copper 12 cents, however, as it was a year ago, it would mean the question of but a short time until aluminum would be produced in sufficient quantity to be on the same basis. The cost of aluminum is absolutely dependent on the amount of the metal produced, just as in any other manufacturing business the fixed charges per unit are dependent on quantity.

Besides an actual cost in favor of aluminum conductors, there is the added advantage of but one-half the weight on the line. The increase in section of 40% means only an addition of one-fifth the diameter—not a very important factor in aerial work. For conduit or underground installations in cities aluminum is somewhat handicapped at present.

The question of galvanic action is probably the greatest disadvantage in the commercial application of aluminum for a number of pur-

poses. In fact most of the disadvantages in its use can be traced to the position of the metal in the electro-chemical series. For instance, in replacing copper wire or cable with aluminum, the question of joints is one of the first that suggests itself, and the problem of soldering aluminum comes to the front. As a matter of fact, aluminum can be soldered, but it is not an entirely satisfactory process, particularly if the soldered surfaces are depended upon for the tensile strength of the joint. With the jointing of large feed wire cable or in smaller conductors, power transmission wire, or electric light feeders, this condition is readily and safely met. In the former instance a sleeve is used in which the soldering necessary is not depended on for strength, but only to obtain a perfect electrical contact. The cable is expanded and the strength of the joint depends entirely upon the mechanical properties of the sleeve rather than directly on the solder. In the latter case the ordinary McIntyre or twist joint is used with a sleeve of aluminum tubing. This twist joint can be used in as large as No. 00 wire or its stranded equivalent. With trolley wire and many parts of electrical machines, such a dodging of the necessity of solder is out of the question, and so far no very extensive experiments have been made to overcome this difficulty. It is the writer's idea, however, that the true solution of this problem will lie in taking advantage of the softness and compressibility of aluminum. It is entirely practicable to put a cable and a sleeve under pressure and reduce the size so that the parts become practically one piece.

As before stated, the two principal fields in which aluminum has extended use as an electrical conductor are power transmission wire and railway feeders. Telephone and telegraph wire is still in an experimental stage, and trolley wire and conduit work present too many difficulties to be successfully overcome when there is but a comparatively slight margin in cost.

As a sample of the specifications which aluminum is called upon to fill as a conductor, the following is an extract of some of the principal clauses upon which several lines have been erected:

Conductivity.—The conductivity of the aluminum furnished will be guaranteed to be not less than 60 in the Matthiessen Standard Scale. Upon this basis the comparative cross-section between copper and aluminum of equal conductivity will be as 100 is to 161.7 (conductivity of copper assumed to be at 97).

Tensile Strength.—The tensile strength of the aluminum wire will be guaranteed to be not less than 22 000 lbs per square inch, with an elastic limit of one-half the ultimate.

Composition.—A uniform product will be guaranteed, the chemical composition of which will not vary more than 0.3 of 1 per cent. The average analysis of the aluminum to be used could be safely taken as

Aluminum	99.6	per cent.
Iron	.15	"
Silicon	.25	"

Joints.—The conductivity and tensile strength of the joints in the line will be guaranteed.

Ductility.—(Wrapping Test.)—Wire shall be capable of being wrapped in six turns around its own diameter, unwrapped, and again wrapped in six turns around its own diameter in the same direction as the first wrapping, without showing any cracks.

As to the corrosion of aluminum or its lasting qualities under atmospheric conditions, there are many opinions held that are absolutely erroneous. Aluminum will corrode under certain conditions; there is no question about that. Salt water, or rather sea water, will affect it, and the presence of ammonia or strong alkaline vapors will corrode it. The fact is, however, that most opinions on this subject are based on the behavior of the metal as manufactured two or three years ago, when a purity of 98% was the greatest available. A very small percentage of impurity causes relatively great corrosive action, and a very pure metal is very much less affected than an impure metal. If an aluminum wire were stretched across a bay, for instance, or in a locality where salt water vapor would come in direct contact with it, it could hardly be said that it would be absolutely non-corrodible. Copper itself will corrode when the atmosphere is sufficiently impregnated with salt vapor. Under ordinary atmospheric conditions, aluminum covers its surface with a film of oxide, which arrests any further corrosion of a granular nature, and this film does not interfere with the conductivity of the wire. Mr. Arthur Hale, Superintendent of Telegraph of the Pennsylvania Railroad Company, writes as follows regarding some aluminum wire he has up west of Philadelphia:

"We have been waiting with some interest to see how the aluminum wire which we recently procured from you would act during the

winter. The first severe test came on Sunday morning after a severe snow storm followed by a drop in the temperature and high northwest wind. The 17 miles of your wire, which we put up, stood the test very well and broke only at one point where there was a slight flaw in the wire."

This particular wire crosses salt marshes and has so far resisted any tendency toward granular corrosion.

Other examples could be cited, as there are many plants using aluminum wire that has been up at least two years.

We have still a great deal to learn with regard to the question of aluminum wire drawing. So many of the physical properties of conductor wire depend on the proper manipulation of the metal in the casting of wire bars and other processes, that it is difficult to predict what requirements can be introduced when this process has had the years of experience that the mills drawing copper wire have had.

The tensile strength and conductivity are largely dependent on the question of the alloying with the addition of a small amount of copper. As small a proportion as $\frac{3}{4}$ of 1% will cut down the conductivity to 56 or 57%, but will correspondingly increase the tensile strength from 22 000 to 35 000 lbs. and even higher. With the idea of showing how firmly this use of aluminum has become fixed, it can be stated that there is being used now no less than 300 000 lbs. a month of alumimum wire and cable for this purpose and the one principal mill is stocked with orders far ahead. The field is an enormous one, particularly with aluminum constantly dropping in price, and copper, at least, stationary.

Another large use, not, of course, as interesting to you as engineers, is the replacing of zinc by aluminum sheet. Just recently one of the large manufacturers of fruit jars has adopted the metal in place of zinc as a fruit jar cover, and you will be surprised to know that the number of fruit jars that are made by this one concern, aside from the industry as a whole, require 6 000 lbs of aluminum a day.

The use in yacht construction is by no means small. On the authority of Herreshoff and other yacht builders, there seems to be no doubt that, properly protected from the direct action of sea water by some good metallic paint, the metal is very satisfactory.

A decided innovation is the replacing of the costly stones for lithographic work by the much more inexpensive aluminum plates. The

principal comic weeklies are the product of such plates. There promises to be great development along this line in the near future.

There are many other legitimate uses that the metal is and will be specially adapted for, but the most interesting ground has been covered, particularly from an engineering standpoint. Aluminum has recovered from the condition consequent to the extravagant and mostly disproved claims made for it soon after its first commercial introduction. The field that lies before it is vast—new properties and new alloys are constantly being developed. The progress will be slow, however. Prejudice is not easily overcome among conservative manufacturers, and most of the labors of development will fall, as it has before, on the producing interests.

DISCUSSION.

Mr. N. P. Lewis.—The author told us the present commercial price. I didn't catch it. He gave what he said was a fair price. I would like to ask what the price is for my own benefit. Mr. Lewis.

Mr. S. K. Colby.—The price was not mentioned, simply because it is largely a question of special conditions. The price to-day will compare very favorably with the higher priced metals. In fact, it is about 10% cheaper than brass. With copper at the present prices, cheap brass will cost from $15\frac{3}{4}$ to $16\frac{1}{2}$ cents per pound; and, taking into consideration the difference of weight, aluminum is considerably cheaper. In general, if bought in sufficient quantities, aluminum can be furnished at from 34 to 35 cents a pound. A year and a half ago it was 50 cents; and two years before that it was 75 cents to $1. Mr. Colby.

Mr. H. S. Wynkoop.—It has been stated that there are two methods by which the production of aluminum may be cheapened. One is in the cheapening of the cost of mining and transporting the raw material. The other is in the cheapening of the cost of electrical energy, required for producing. This raw material can be procured from Tennessee down to the northwest of Georgia for almost nothing, but this raw material has to go over railroads which charge very high rates, and it will probably be a long time before the railroads down there are doing sufficient business to lower their rates, so as to reduce the cost of the bauxite if delivered at the point where the process of manufacture is carried on. Mr. Wynkoop.

Mr. S. K. Colby.—I want to correct one statement made by the gentleman who spoke last, that is, in regard to the territory in which bauxite is found. The actual territory in which bauxite may be found is very much less than the area he has indicated. The majority of the bauxite found outside of Georgia and Alabama contains over 3% of silica, from which it is impossible to produce aluminum commercially because of the difficulty of getting rid of the silica. In the purification it is impossible to dissolve it, or, I should say, to leave as a residue in the process much more than 3% of this silica, and, in consequence, if the alumina that goes into the pots contains any silica, that silica comes down with the aluminum in the process of reduction. In consequence, we get, in the first place, metallic silicon which we do not want, and, in the second place, an aluminum which is contaminated with silicon and which gives a useless product. Although Mr. Wynkoop's statement is perfectly true that there is bauxite in the territory he mentions, it contains more than 3% of silica, when it should contain under 3%, and some of it runs as low as $1\frac{1}{2}$ to 2 per cent. Mr. Colby.

Mr. Wynkoop. Mr. H. S. WYNKOOP.—May I ask the price of the raw material, as mined, and the price per pound for transportation. I want to get the relative amount.

Mr. Colby. Mr. S. K. COLBY.—The cost of mining that material is about $2.25 to $2.50 per ton on board cars. The value of the land on which these bauxite formations are found is about $300 an acre; that depends on the man one has to deal with, of course. He generally puts his price away up. The ordinary value, I should say, at the present time, for bauxite formations of that character ranges from $300 to $500 per acre. The cost of transportation of the raw material is from $6 to $8 per ton in Pittsburgh; but $6 a ton is only a very small item in the actual cost of the alumina. The process of purifying the bauxite is what costs most.

A Member. A MEMBER.—I would like to ask whether I understood Mr. Colby correctly with regard to the statement he made that the price of electric power per horse-power per hour is $12.

Mr. Colby. Mr. S. K. COLBY.—I made no definite statement as to $12 per horse-power per hour. As a matter of fact I am not in a position to state what the cost of horse-power is exactly. I merely stated that, taking those figures as a basis, the results indicated are obtained.

The President. The PRESIDENT.—I would like to ask Mr. Colby what proportion the aluminum that actually comes into the process of reduction bears to the bauxite from which it is made?

Mr. Colby. Mr. S. K. COLBY.—The proportion varies from 48 to 50%, and a peculiar fact in this connection, as before stated, is, that not more than ½ of 1% of the original aluminum is lost in the reduction.

A Member. A MEMBER.—Will aluminum be satisfactory for trolley wire?

Mr. Colby Mr. S. K. COLBY.—We have had several offers from electric railway companies to put in an experimental section of aluminum trolley wire. Up to the present time, however, we have not been quite ready to accept such offers, because we have not been sure enough of our ground. The question of wear must be determined. Aluminum is a soft metal and does not wear nearly as well as a hard copper wire. And yet, while not actually a good bearing or wearing metal, we have had some rather contradictory results.

The question came up some time ago of the manufacture of an aluminum back or frame for the clocks manufactured by a large clock company, replacing the heavy brass that is used for the frames, and of which a great many tons are used every year. We tried the experiment of putting aluminum under the friction test, and they ran their experimental clocks some nine hundred and ninety-nine years in the space of twenty-four hours, by gearing up the wheels, and the actual wear of the steel pinions on the aluminum plate was less than on a brass plate under the same conditions. This question of wear is a very important one in trolley wire, and the result of the first experiments along this line will be watched with great interest.

BROOKLYN ENGINEERS' CLUB.*

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THE NEW YORK BUILDING LAW IN RELATION TO TALL BUILDINGS.

By Robert C. Strachan, M. B. E. C.

Presented October 12th, 1899.

The statement that the New York building law, concerning buildings of the "sky-scraper" type, should be revised, has been made so frequently that it is unnecessary for the author of this paper to disclaim originality for the idea. What follows is simply a reiteration of arguments which have been already advanced, with perhaps a difference in the form of presentation.

The process of designing the skeleton for a modern office building is one which involves as great a degree of skill and judgment as would be required in the design of an important bridge, with perhaps a greater attention to those matters of details which, to the owner or architect, might appear unimportant. This is due to the fact that in a building of, say, fifteen stories, there are many more duplications of parts than would ordinarily be found in a bridge containing an equal weight of steel. Hence, a trifling waste of material in one beam section becomes very evident when multiplied by the number of duplications.

But in this, as in most engineering operations, theoretical considerations do not always govern. The design must conform to the building law. The fact must be borne in mind that the present regulations were framed at a time when a building ten stories high was not

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among the probabilities, nor had the present state of knowledge in regard to the materials of construction been then attained.

However we may wonder that the first city in the Union, the city in which the economic necessity for erecting tall buildings was first manifested and is now most strongly felt, should for so many years have contented itself with a building law which it had outgrown, we are less surprised, when we recollect all this, to find that a structure designed under the provisions of this law, can hardly be called modern in all respects. The statute comprising the building laws is a remedial statute, and is to be construed liberally. Under its authority the official head of the Building Department may disregard some obsolete practices, and cause changes to be made in methods of calculation. But this may often bring expensive trouble and delay to a designer unacquainted with the practice of the department.

Beginning with the foundations, let us consider the present legal requirements as to some parts of a skeleton building.

Section 474 provides that bearing piles shall be not less than 5 ins. in diameter at the small end, shall be spaced not over 30 ins. between centers, and shall not be loaded with more than 40 000 lbs. each. It is evident that under this section, piles 5 ins. in diameter at the large end might be used and loaded with 40 000 lbs. The worst feature, however, is that no account is taken of the factors which are most important in determining the supporting power of the pile, viz., the character of the soil, the penetration of pile under the last blow, the weight of the hammer and the height from which it falls. Without entering on a theoretical calculation, based on any one of the numerous pile formulas, the mere statement that the supporting power of a pile driven 12 ins. by a hammer weighing 1 000 lbs. falling 10 ft. is vastly inferior to that of a pile driven 1 in. by a hammer weighing 2 000 lbs. falling 20 ft. is so obviously true as to need no further demonstration.

The presence of pile specifications in the building laws of other large cities, almost identical with the section cited, shows the force of a bad example when set by an influential individual, whether private or corporate. As an instance of some other ways of covering the pile question, the building law of a certain large city requires that any pile foundation shall be sufficient to support the superstructure; which is no doubt eminently safe from a legal point of view, and so general as to be impregnable to the assaults of adverse criticism.

In Section 474 the size of stone footings under columns is fixed as being 12 ins. wider on all sides than the base of the column, and the minimum size of stones is stated to be 2 by 3 ft. by 10 ins. The projecting part of the stone footing acts as a cantilever uniformly loaded. Specifying that this shall not have less than a certain length, while evidently intended to limit the pressure on the earth below the footing, has the effect of allowing very high tensile stresses in the stone, if we draw a fair inference from the wording of the section, and use one course 10 ins. thick, projecting 12 ins. beyond the column base. To illustrate, assume a column carrying 100 000 lbs. The area of footing at 4 tons per square foot (see Section 483) would be 12.5 sq. ft., say 3 ft. 7 ins. by 3 ft. 7 ins. If this is to be 12 ins. wider on all sides than the column base, the latter would then be 1 ft. 7 ins. by 1 ft. 7 ins. With this arrangement, the tensile stress in the stone would be 234 lbs. per square inch, which condemns the design at once, for the footing should be of such dimensions that this stress is insignificant. With a projection of 12 ins. the depth necessary to accomplish this gives a much larger and more expensive pier than would be required if the column base were increased in area until the depth of 10 ins. sufficed, and it lies in the discretion of the Commissioner of Buildings to decide which course to pursue in a particular case.

The question of the amount of live load to be provided for in designing floors is one which will naturally be governed by the prevailing conditions in a given city. Hence, the specification of 70 lbs. per square foot, which is used in several large cities, furnishes no argument against the New York law calling for 100 lbs. per square foot, which is probably not too great. Floors subjected to the vibrations of machinery should be specially designed; but in ordinary cases, the use of the same unit stress for both live and dead loads is correct. For while the live load on a bridge is that which may be applied for a short time, and may then be absent for hours or days, the live load on a floor consists, in large part, of office fixtures, the positions of which remain unchanged for years. The theory by which, in designing bridges, the live load unit stresses are fixed at one-half the dead load unit stresses, will therefore, not apply, for the removable load, during long periods, is as quiescent as the weight of the structure.

But in dimensioning floor beams and girders in New York, we are governed by a section (486) which in one paragraph states that steel

girders may be designed for a stress of 15 000 lbs. per square inch of the gross section of the flange, and in another, that not more than one-half of that portion of the flange angle which lies against the web may be regarded as flange area. The effective depth of a girder 5 ft. over angles may vary by 2 ins., as calculated by these two paragraphs, a difference which would very materially affect results. The practice of the department in Manhattan has been to follow the second method, that is, to deduct one-half of the vertical leg. Under modern specifications, the net area is obtained by deducting from the gross area the portion removed in punching rivet holes, assuming that the hole is $\frac{1}{8}$ in. larger than the rivet; and girders so designed are amply strong.

Take the case of a girder of 23-ft. span, $2\frac{1}{2}$ ft. over angles, carrying 3 000 lbs. per foot, and let us design the flanges (1) for a stress of 15 000 lbs. per square inch of the gross area; (2) for a stress of 15 000 lbs. per square inch on an area deduced according to the method of the department; (3) according to modern methods, using 15 000 lbs. per square inch of net section. We then have:

First.—Flange stress 83 000 at 15 000 = 5.5 sq. ins., for which we may use two 4 by $3\frac{7}{16}$-in. angles having an area of 5.74 sq. ins.

Second.—By cutting off one-half of the vertical or 3-in. leg, the effective depth is slightly increased and we have a flange stress of 81 500 at 15 000 = 5.4 sq. ins., requiring two 4 by $3\frac{9}{16}$-in. angles, having an area of 7.24 sq. ins., or, after deducting two legs $1\frac{1}{2}$ by $\frac{9}{16}$ in., a net area of 5.56, an increase of 26% in the flange.

Third.—Flange stress 83 000 at 15 000 = 5.5 sq. ins., requiring two 4 by 3 by $\frac{1}{2}$-in. angles with a gross area of 6.50 sq. ins., or, after deducting two holes, $\frac{7}{8}$ by $\frac{1}{2}$ in., a net area of 5.62 sq. ins.

The increase by the second method over the result obtained by the third is then 11 per cent. That is, in order to satisfy the Department of Buildings, we must put into the flanges of every such girder 11% more material than would be considered necessary under any modern specification, even though using the same unit stress. For heavier girders, without cover plates, this percentage would be increased.

Besides these faulty methods imposed by the present law, it makes no distinction between bolts and rivets, nor between field and shop rivets, nor between steel rivets and iron rivets. All are included under one head as being good for 9 000 lbs. per square inch in shear. No bolt should be considered equivalent to a rivet of the same mate-

rial and size, unless turned to a driving fit; many engineers object to the presence of bolts in important connections even when so turned. As to field rivets, outside of buildings in New York City, the practice is universal to allow for them not more than 80%, and usually 67% of the value of a shop-driven rivet. For it is very clear that no hand workman can exert the power which may be brought to bear with a riveting machine, to upset properly the material in the shank and cause the plates to be firmly gripped. No inspector would expect to find eccentric heads and loose rivets among those driven by machine in any reputable shop. It is safe to assert, that if there are any rivets in a structure, which are not doing the work they should do, they are hand-driven. Hence, we may, under the New York law, after putting into a girder enough material to give it a large excess of strength, have a large deficiency in the strength of its connections to its supports.

The designing of columns is covered in the building law by Section 483, which states that their strength shall be computed by Gordon's formula. The form of this formula is:

$$\text{Crushing load} = \frac{\text{Coefficient} \times \text{ area of section.}}{1 + \left[N\left(\frac{L^2}{D^2}\right)\right]}$$

In which L is the length of column in inches; D is the diameter of a round or the least side of a rectangular section in inches; and N is a factor depending upon the condition of the ends of the column, the material, and the form of the section.

The law states nothing whatever about the value of N to be used in any case, though specifying the coefficients to be used in the numerator, for columns of cast iron, wrought iron, steel, and various woods.

Up to a recent date it has been the custom of the department to calculate working loads per square inch by the following:

$$\text{Riveted steel, } W = \frac{12\,000}{1 + \frac{L^2}{36\,000\,R^2}}$$

in which the denominator agrees with that used in the usual specification for fixed ends, R being the least radius of gyration.

$$\text{Hollow, round cast iron, } W = \frac{16\,000}{\frac{L^2}{400\,D^2}}$$

Hollow, rectangular cast iron, $W = \dfrac{16\ 000}{1 + \dfrac{L^2}{500\ D^2}}$

The following table shows a few comparisons between safe loads for cast-iron columns, obtained by various formulas. The figures for Chicago and Boston are taken from tables published by The Expanded Metal Fireproof Construction Company.

Size. Inches.	Length. Feet.	Type.	New York Law. Tons.	Boston Law. Tons.	Chicago Law. Tons.	Carnegie Pocket Book. Tons.
6 x ¾	10	Round.	50	41	37	33
6 x ¾	10	Square.	70	58	53	....
9 x 1	16	Round.	94	80	71	64
9 x 1	16	Square.	134	112	103	....
12 x 1½	18	Round.	219	176	161	141
12 x 1½	18	Square.	306	242	225	....

The actual loads are probably somewhat less than the calculated loads, for in New York we must assume all floors borne by a given column, to carry full live and dead load simultaneously. The building laws of many cities provide that in calculating column loads, a certain percentage may be deducted from the specified live load capacity of floors. This is a reasonable method of taking account of the fact that there will always be some portion of the building which is not fully loaded.

But under a very small load, the behavior of a cast-iron column is uncertain, though its manufacture may have been conducted with great care. On account of this notorious unreliability, due, principally, perhaps, to the internal stresses arising from unequal cooling, cast iron has long been discredited among bridge engineers, as a structural material, bed plates and similarly situated parts being the only ones for which its use is allowed. A building law framed with due regard to the known characteristics of cast iron, should restrict its use to buildings of lesser importance, and reduce the present allowed column loads very materially.

Since the foregoing was written, the Building Code Commission appointed in January, 1899, for the purpose of revising the building law, has made public its report to the Municipal Assembly. The new code recommended in this report, whatever legal defects it may con-

tain, is, from the engineer's standpoint, so far as it relates to tall buildings, a great improvement over the old. The superiority arises in great measure from its definiteness. The subjects are treated in such a manner that, however opinions may differ regarding the wisdom of its requirements, there is little doubt as to what is required. This merit will appeal to any one who has been compelled to revise a set of plans in consequence of the ambiguity of some section of the law. The subject of wind pressure, heretofore ignored, is also covered. It is to be regretted, however, in view of the likelihood that the proposed code will become law, that under it the use of cast iron columns is as freely allowed as at present, and that the safe loads specified are a little higher than those heretofore allowed under the rulings of the Building Department.

One of the most far-reaching changes proposed by the new code is that concerning fireproof floors. Up to a very recent date, it has been practically impossible to make use in skeleton buildings, of any but solid or hollow brick arches, covered with concrete, between floor beams, the latter form giving a completed floor weighing about 80 lbs. per square foot. Other styles of floor have been designed, equal to this in durability and carrying capacity, and having a weight of but 50 lbs. or even less. The new code allows the use of any form of fireproof floor which has previously been tested and approved by the Building Department. When we consider that a reduction of 30 lbs. per square foot in a building 100 by 50 ft. with ten floors, is equivalent to a reduction of 750 tons in the dead load carried upon the foundations, making possible a large saving in metal for both columns and beams throughout the entire building, the importance of such a change is apparent.

Whether the effect of Section 148 of the proposed law, which gives the Commissioner large discretion, will be to nullify its good points, is a problem for lawyers rather than for engineers. But assuming that such will not be the case, its passage will, no doubt, cause great and long-needed changes in the construction of tall buildings; changes which should be felt by the owner, the architect and the engineer through opportunities for more economical design.

DISCUSSION.

Mr. Meem. Mr. J. C. Meem.—I find in the tables for cast-iron columns as published in Carnegie's hand book in 1893 (which may have been revised since) that the loads given there for those columns, in which the ratio of the length to the diameter is the same as in those of some recent experiments made at Phœnixville, Pa., are from 33 to 50% too large per square inch of area. I should like to ask how these tables compare with the old New York building law.

Mr. Strachan. Mr. R. C. Strachan.—I do not know what the old Carnegie tables give, but those in the edition of 1896 give safe loads about two-thirds as great as the old New York law allows. Do I understand from these experiments that a column calculated for 57 000 lbs. per square inch ultimate strength showed an actual strength of only 28 000 to 38 000 lbs.?

Mr. Meem. Mr. J. C. Meem.—That is, I think, what they showed. The experiments referred to were made by the New York Building Department, under the direction of Mr. W. W. Ewing, at the Phœnixville Bridge Company, Phœnixville, Pa., December 15th to 21st, 1897. Those interested in the subject are referred for a full account to the *Engineering News* of January 13th, 1898, from which the following deductions are quoted. "That is, by the New York law the 15-in. columns would be calculated to have a breaking strength of 57 143 lbs. per square inch, while the actual tests show that their strength was only from 24 900 to something over 40 400 lbs. per square inch. The 6 by 8-in. would be calculated to have a breaking strength of 40 000 lbs. per square inch, while their actual breaking strength was only 22 700 to 31 900 lbs. per square inch. If such columns as these are loaded in buildings with the loads the law allows, the factor of safety instead of being 5, as required in the law, is actually in some cases little more than 2. This is also borne out by the results obtained during similar tests conducted about a year ago by the Building Department with full-sized cast-iron columns."

The *Engineering News* says in effect in a later issue, it is not generally known that the only basis for Gordon's and Rankine's formulas, with their different coefficients as given by various authors and upon which are designed all the columns used for buildings in New York City, is a series of experiments by Hodgkinson on nine "long" pillars 7½ ft. long, with external diameters of 1.74 to 2.23 ins., and whose greatest thickness was 0.35 in., and on thirteen "short" pillars 0.733 to 2.521 ft. long, with external diameters of 1.08 to 1.26 ins., and whose thickness was in no case as great as ¼ in. The strength per square inch of a piece of cast iron varying with its fineness of grain, which depends on its thickness and rate of cooling as well as its composition, it is not possible to predict, from a piece

$\frac{1}{4}$ in. thick, what will be the strength of a piece of the same iron 1 to $1\frac{3}{16}$ ins. thick—the thickness used in modern 15-in. columns ? Mr. Meem.

Mr. S. O. Miller deduced a formula from the Phœnixville tests as follows: $P = 34\,000 - 88\ (l \div r)$ in which P is the ultimate load per square inch, l is the length in inches and r is the least radius of gyration in inches. Applying this to the 15-in. column, noted above, we have l equals 190 ins. and r is 7 ins. approximately. Then P equals 31 739, which is practically a mean of the extreme results, 24 900 and 40 400, given by the experiments.

Mr. Strachan. Mr. R. C. Strachan.—The principal objection, as I think I stated, is that, although you may figure on cast-iron columns any way you please, you don't know what a given column is going to do. Therefore, you ought to allow a liberal factor of safety; and if you eliminate the cast-iron column from important buildings, so much the better.

A Member. A Member.—Perhaps Mr. Strachan can tell us something about his investigations in the Ireland Building.

Mr. Strachan. Mr. R. C. Strachan.—Some of the broken columns in that building showed that the core had shifted so that the metal on one side would be perhaps $\frac{5}{16}$ in. thick, where it was supposed to be $\frac{3}{4}$ in.; consequently, the strength of the column wasn't anything near what it should be. I do not think there was one that I saw in which the core had not shifted very perceptibly.

Mr. J. Strachan. Mr. Joseph Strachan.—I would like to ask the speaker of the evening if he thinks cast-iron columns would not be perfectly safe up to, say, 12 ft. in length, cast on end, just like cast-iron water pipes. The thickness of water pipes is quite regular, and there are comparatively few failures due to pressure. It seems to me that cast-iron columns, for buildings, up to that length would be as safe as wrought iron.

Mr. Strachan. Mr. R. C. Strachan.—That is the important point in my mind—to cease the use of cast-iron columns promiscuously in large and important buildings, like the Syndicate Building on the corner of Nassau and Liberty Streets, where there are sixteen stories on cast-iron columns. Of course cast-iron columns stand up for a long time, but there is always the possibility of a sudden side-blow destroying them.

Mr. Seaman. Mr. Henry B. Seaman.—My opinion of cast-iron columns is quite different from that expressed by Mr. Strachan. If a cast-iron column is properly made and carefully inspected, and is designed so as not to put a tensile strain upon it, I think it may be a better column for ordinary building purposes than a wrought-iron column. The reason for that statement is that it is usually a thicker column and will resist heat better. The fire test of wrought iron and cast iron shows the wrought-iron column to fail in less than half the time of a cast-iron column. This is a very important consideration in building con-

Mr. Seaman. struction. The greatest danger from the use of cast-iron columns arises from lack of proper inspection. It is important that the test holes be drilled in the bottom and top of the column as it is cast, because if the core shifts it usually rises. When holes are drilled in the sides, they fail to reveal this defect, and many columns are accepted, in which the core has shifted.

Mr. Strachan. Mr. R. C. Strachan.—Mr. President, my objections may be summed up in just this—that, however good some cast-iron columns may be, we do not know in general whether they are good or not, and so cannot design intelligently, because, in order to design intelligently, we must know what the material is doing and be well satisfied that our calculations will be carried out in fact.

The President. The President.—Is the only defect you have got to look out for the floating core?

Mr. Strachan. Mr. R. C. Strachan.—No. You must also be sure that there has been no unequal cooling. There may be unequal cooling without shifting of the core.

Mr. Tillson. Mr. George W. Tillson.—I would like to ask Mr. Seaman if he considers it just as easy to properly inspect a cast-iron column as one of wrought iron. I had a little experience a long time ago in the construction of buildings, and it was found then almost impossible to tell whether a cast-iron column was free from defects or not before it was used, and practically the only way to be sure of it was to put on the needed pressure and give it the actual test. In addition to the danger of the shifting core and unequal cooling there might be some blow-holes on the inside that could not be detected, and some defects in the casting that would not show, except on a very thorough and competent inspection. For these reasons it was considered unsafe, and there wasn't the certainty about using cast iron as there was in using wrought iron.

Mr. Seaman. Mr. Henry B. Seaman.—There is no certainty about it. That is the reason we use the higher factor of safety. A wrought-iron column is built up in detail, each plate is inspected, and for that reason you cannot inspect the cast-iron column as thoroughly as you can the wrought-iron column. In regard to tensile strains, eccentric loading does not necessarily cause tensile strain. The increase of compressive strain on the near side, or the decrease on the far side, is a matter of calculation.

Mr. Strachan. Mr. R. C. Strachan.—I think, Mr. President, that what I said still holds good, that the objection to the promiscuous use of cast-iron columns lies in the fact that we cannot design intelligently.

Mr. Orrok. Mr. G. A. Orrok.—At one time I had a little experience in cast-iron columns. I had to design a good many of them, but I believe in using them as little as possible. I used to make water pipe once on a time. We made water pipe up to 36 ins. in diameter, and I know how

hard it is to get the core to stay in place. Many pipes are thrown out in the foundry after inspection. Those pipes are cast on end. Every care is used to ensure good casting; the mold is made properly; they are all dried, and everything is arranged so that you get the very best results, but even then the core shifts. I have never known of a foundry that would not average 5% of rejected pipe. Now, if that is true of pipes with all the care that is exercised, what must be said of cast-iron columns usually cast on the side. Where there is one cast-iron column cast on end there are a hundred cast on the side. If you could bore holes every 3 ins. all through your column you might possibly inspect that column properly. I usually went all over the column to find out whether it was the same thickness all the way around. Another point I wish to call attention to. You may have a cheap laborer and perhaps his attention is called away and a lot of ashes and cinders get into the center of the column that you don't know anything about. I don't think a cast-iron column can be depended upon above 6 ft. Mr. Orrok.

Mr. HENRY B. SEAMAN.—The cinders will usually come to the surface. Mr. Seaman.

The PRESIDENT.—It suggests itself to me that the possibility of a thorough test with water pipe is very much more feasible than it is with any kind of a column. The President.

Mr. HENRY B. SEAMAN.—All columns are drilled; water pipe is not. Mr. Seaman.

Mr. G. A. ORROK.—There is still one other point. You can have a chemical test of the metal that goes into your columns, and can estimate its value. Sometimes good scrap is used and sometimes bad scrap. Mr. Orrok.

Mr. J. C. MEEM.—I find in the proposed New York Building Department laws, as just revised and published, that the specifications for Portland cement are, solely, that it shall stand a tensile stress of 120 lbs. per square inch after twenty-four hours in air, and 300 lbs. per square inch after twenty-four hours in air and six days in water. I do not consider this a satisfactory definition for Portland cement, as a natural cement might, and doubtless could, be found to comply with these specifications, in which case it could be substituted for Portland cement, with, perhaps, disastrous results, especially if the work was under water, or of any other class requiring true Portland cement. Mr. Meem.

Mr. R. C. STRACHAN.—I think that is rather a high tensile strain to call for in Portland cement; 100 lbs. in twenty-four hours is looked on as very good. The question of cement will be more important in case this code becomes a law. One type of floor for which very strong efforts have been made in New York is the expanded metal floor, which consists of a metal mesh, formed of a plate cut in a certain way, the meshes being filled with concrete. Now, a floor formed in this way, Mr. Strachan.

Mr. Strachan. with about 3 ins. of concrete, has been tested to over 2 000 lbs. to the square foot, the resultant distortion being, of course, permanent. The question of cement, therefore, in the new regulations will be much more important than it was in the old, as such floors heretofore have not been allowed at all.

The President. The PRESIDENT.—Did I understand the author to say in his paper that a floor could not be built of concrete, except with bricks?

Mr. Strachan. Mr. R. C. STRACHAN.—That has been the ruling of the Department.

The President. The PRESIDENT.—A monolithic arch couldn't be built of concrete?

Mr. Strachan. Mr. R. C. STRACHAN.—It wasn't allowed in New York City. The preference always was for a hollow brick arch covered with concrete. The makers of different floors have tried to introduce some that are much superior to the hollow brick form, and have shown by tests that these floors were fully capable of sustaining everything they would be called upon to sustain, but they have not been allowed to use them.

The President. The PRESIDENT.—Then a solid concrete arch between beams, without any dependence on expanded metal, or wire mesh was not allowed?

Mr. Strachan. Mr. R. C. STRACHAN.—No, sir.

The President. The PRESIDENT.—Is there a valid objection to that?

Mr. Strachan. Mr. R. C. STRACHAN.—There is no valid objection to any form of floor which shows under a test that it will hold what it will be called upon to hold. Notwithstanding such tests, the department has always preferred one form of floor.

The new code, I think, is also superior in its method on the subject of cast-iron columns, assuming that cast-iron columns might sometimes be used advantageously. The new code, instead of saying in a general way, that we must use Gordon's formula, states what load per square inch to allow on a column of given length and diameter. That, of course, takes away all ambiguity.

Mr. Tillson. Mr. GEORGE W. TILLSON.—I think it is best in specifying tests for cement, not to require a cement to show a certain strength in twenty-four hours, and then a certain strength in a week, but to say that if it sustains a certain amount in twenty-four hours it must sustain a percentage amount in seven days. That is, make the seven-day test dependent on the twenty-four hour test to a certain extent.

I am sorry I haven't the figures, but I saw, a short time ago, a statement made in the journal of an engineering society, where a man gave his experience in some cements that he had accepted and rejected on a week or thirty-day test. He continued his tests for a year and found that the cements which he had rejected on the result of his thirty-day tests were very much stronger at the end of the year than the cements which were accepted. He found that his thirty-day tests did not amount to anything, and that, I imagine, is the experience of almost every engineer—that you cannot tell anything about a test of cement for thirty days, or three months even, if you know nothing

about the cement. You must have a longer test, at least a year to get any result that is of any value whatever. Mr. Tillson.

Mr. R. C. Strachan.—The photograph which I have here may be of interest. It shows a floor made with expanded metal and concrete, supporting a load of 2 300 lbs. per square foot. The introduction of this style of construction in the building of floors will lead to a great lightening in the skeleton. If we can make floors weighing 30 lbs. per square foot, where we have been accustomed to have 80 lbs., we shall save a great deal on the skeleton, and have just as good a building when we get through. Mr. Strachan.

The President.—I think the last remark will apply to highway bridge construction where solid floors are put in to carry paving. It would lighten the weight of the substructure. The President.

Mr. Henry B. Seaman.—The matter of patents is of the greatest interest to the general practice of engineering at present, and if these patents are of no value, the profession wants to know it. There is a house in Port Chester belonging to Mr. Wm. E. Ward, which was built about thirty years ago of iron and concrete. The entire house is a monolith. Mr. Seaman.

The President.—I have heard there is a bridge in Prospect Park that is partly of iron and partly of concrete, and built according to some system entirely different from anything we have been talking about. The same man built it that built the old fountain at the Plaza. The bridge I refer to was built to take the place of the old wooden bridge near the well. Does anybody know anything about its construction? I am sure the ribs are of wrought iron. The President.

Mr. W. S. Tuttle.—I do not know that I can add anything to the discussion. I know there is a great deal of uncertainty in castings, the blow holes and other defects that have already been mentioned. There is one feature about cast iron that might be considered. That is its durability and freeness from oxidation. Cast-iron columns all have a skin of oxide of iron or silica or something of that kind on the outside which protects the metal very much, and it is a question whether the cast-iron column wouldn't be more durable than the wrought-iron column. Mr. Tuttle.

Mr. George W. Tillson.—Speaking of oxidation, Mr. President, reminds me of what I saw last week. I spent last Friday driving over Rochester, and one of the visits we made was to an iron bridge over the New York Central tracks that had been built seven years. They were repainting it, and on a girder that had been painted and boxed in, the foreman showed a scale that he had taken from this girder that probably had an area of 50 or 60 sq. ins. and was $\frac{1}{8}$ in. thick. He had a good many more, but that was the largest. That was a girder that had been boxed in with wood, had been painted, and had only been up seven years. Mr. Tillson.

Mr. Tuttle. Mr. W. S. Tuttle.—In that same connection we had some truck scales, and beneath the platform there were a number of wrought-iron rods. When it became necessary to repair the scales we found the rods, which were 3 or 4 ins. in diameter, were nearly half gone. The scale had crumbled right from the surface and seemed to have run in lines, as though the cinder, or whatever it was, in making up the wrought iron, had crumbled out. The castings were comparatively perfect, with but little rust on them.

Mr. Seaman. Mr. Henry B. Seaman.—A rust scale $\frac{1}{8}$ in. thick does not mean the taking off of $\frac{1}{8}$ in. of the metal. In regard to the corrosion of wrought and cast iron, I would like to endorse what the last speaker said. With respect to corrosion of wrought iron in buildings it is pretty well known that iron encased with concrete is thoroughly protected, but even where it is merely protected from the outside weather it also seems well protected.

While on the Erie Railroad in 1891, I was instructed to make a test of the Phœnix columns in the Kinzua Viaduct, to ascertain the extent of the rust upon the inside of the columns. I had a piece cut out of the lower end of one of the longest columns of the viaduct and on the inside so that, if there were any water in it, it would flow down at that point. The metal was entirely free from rust, and with the fresh luster of newly rolled iron.

Mr. Provost. Mr. A. J. Provost, Jr.—In connection with floor construction, I saw a floor recently, and one of the details struck me as being rather peculiar. It was constructed of 20-in. steel beams, arches of hollow tiles with filling material of cinders which were covered on top with 3 or 4 ins. of Portland cement. The curious thing to me was that, in laying the cinders, they had mixed them with Portland cement, 4 parts of cinders and 1 part of cement. The cinders were about 8 ins. over the tops of the hollow tiles. I did not see any reason for uniting them with cement. I would like to ask if that is a common mode of construction.

Mr. Strachan. Mr. R. C. Strachan.—That is the usual way of making concrete floors. The cinder concrete makes a lighter floor. Where 20-in. beams are used, the weight would not be much less than 90 lbs. to the square inch, even with cinder concrete.

BROOKLYN ENGINEERS' CLUB.*

No. 21.

RECENT DEVELOPMENTS IN GAS ENGINEERING.

By H. K. Landis, M. B. E. C.

Presented November 9th, 1899.

Just as other methods of lighting have been making gratifying and even radical progress, gas lighting has also developed and left the groove in which it had run for three-quarters of a century. As a consequence its importance is increasing and its place among the so-called public utilities is being regarded more and more every day as not only fixed, but as a necessity for public comfort and happiness. There are about one thousand operating gas companies in the United States having a capitalization, each, ranging from $20 000 to $60 000 000 and delivering about 60 000 000 000 cu. ft. of gas at an average price of probably $1.60 per 1 000 cu. ft. This means the consumption by the gas works of about 4 000 000 tons of coal and 252 000 000 galls. of oil for illuminating gas alone. The gas engineer is not as yet dignified by a degree. Chemists, mechanical and civil engineers drift into the profession because it is a paying business and are thereafter known as gas engineers, but superintendents and managers often appropriate the same title. It is to be regretted that colleges do not offer a distinct course instead of relegating it to one corner of industrial chemistry, and we are glad to see that there is the indication of a movement in this direction. There are ten associations of these gas engineers distributed from San Francisco to Boston, holding annual

* This Club is not responsible, as a body, for the facts and opinions advanced in this publication.

meetings, many publishing proceedings, and their interests are looked after by two gas journals.

Progress was slow until the advent of water gas, which at first was received with open hostility, but now furnishes nearly three-fourths of the output of gas. Coal gas is made by heating bituminous coal to a bright red in a closed retort and thus driving off the volatile portion. In water gas manufacture, steam is blown through red hot coke or anthracite and a mixture of hydrogen gas and carbon monoxide produced. These are the gases sold to-day for lighting purposes. To a very much smaller degree, oil gas, and gas made from wood, rosin, gasoline, etc., are used, and acetylene has still to demonstrate its value for extended application.

For metallurgical heating the various forms of producer gases are employed, although water gas, uncarburetted, is entering the field quite rapidly. Natural gas, probably derived from the metamorphic carbonization of carboniferous deposits, has a high heating value, 1 000 B. T. U. per cubic foot, consists principally of marsh gas, and is extensively used about Pittsburg and through Ohio and Indiana for that purpose, although a great deal of lighting in connection with Welsbach burners is also done with it. It is with coal gas and water gas, however, that we are principally concerned. Both must be enriched or carburetted by adding oil vaporized at such a high temperature as to become fixed gases. By this means the former is increased from about 15 to 22 C.-P., and the latter from a very slightly luminous flame to one of 25 to 30 C.-P.

The luminosity of a hydrocarbon gas, according to the latest theory advanced, depends upon the incandescence of free carbon in the flame. As the gas issues from an orifice it is heated more and more and begins to lose its hydrogen, going from marsh gas ($C\,H_4$) in successive stages through acetylene ($C_2\,H_2$) into free carbon and free hydrogen. The latter burns with a non-illuminating but intensely hot flame, which, in addition to the heat produced by the combustion of $C\,O$, raises the temperature of the free carbon to incandescence, where it remains until it comes in contact with oxygen of the air and is converted into $C\,O_2$. An appreciation of this fact will lead to the understanding of many phenomena connected with flames. In order that a flame shall be luminous it must contain hydrocarbons; and the more concentrated they are in carbon, the brighter will be the flame and also the greater

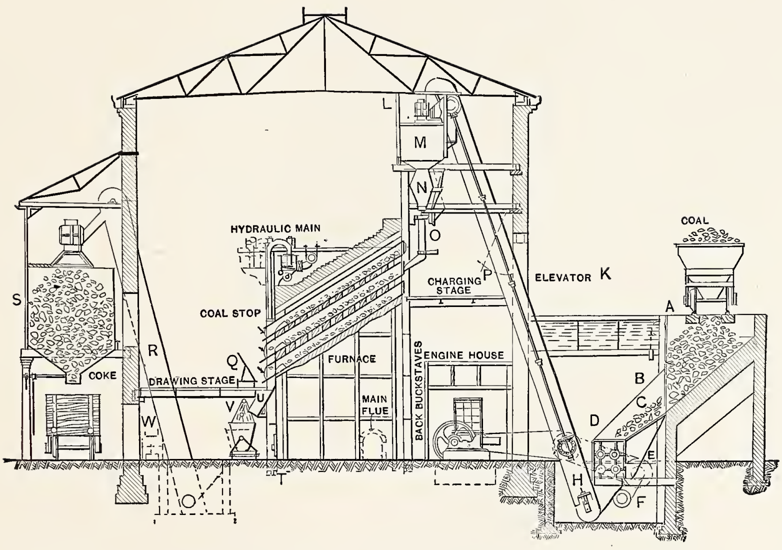

Fig. 1.—Section of Coal Gas Plant Using Inclined Retorts.

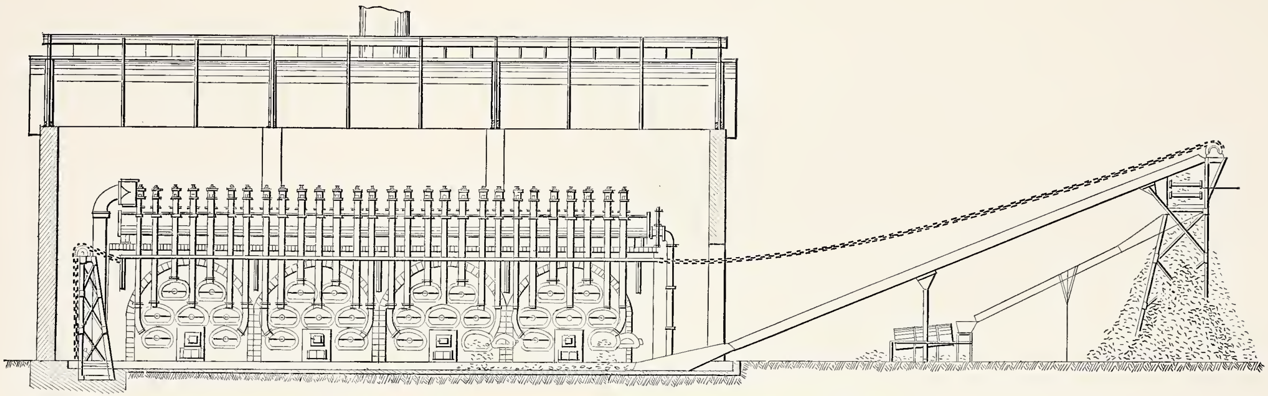

Fig. 2.—The Brouwer Quencher-Conveyor for Gas Coke.

their tendency to form soot. A non-luminous water gas flame or a slightly luminous coal gas flame may thus be rendered bright by the addition of hydrocarbons in the form of oil vapor, naphtha, benzine, acetylene, etc., or the candle-power of a rich hydrocarbon gas may be reduced with more or less success by adding a non-luminous gas.

Coal Gas.

It is about one hundred years since coal gas was used for commercial lighting. Its first use was by practical men, and it really never has occupied much scientific attention. The process of carbonization is so simple that it does not appeal to the intricacy-loving scientific mind. The cast-iron retorts first used have been abandoned long ago, but the method of heating them, and conducting and treating the gas, has changed only in details. The gas is still cooled to remove tar and heavy oils, washed by water to remove light oils and ammonia, and passed through beds of oxidized iron or iron ore to remove sulphur compounds, although lime is sometimes used for this purpose. Improvements have been attempted in the construction of the benches, however. The possible saving of heat by regenerative chambers and recuperators was discussed and some plants put up, but it was found that the expense of construction and repairs and other inconveniences more than offset the saving of fuel effected. The labor of withdrawing red-hot coke from the retorts and recharging with coal is severe, and inclined retorts were devised to make gravity do the work. Such inclined retorts are used extensively in Europe; one example in this country seems neither to arouse interest nor comment, although the question is occasionally agitated. Fig. 1 will give a general idea of the construction of this system as installed in England. The coal falls from the car into a hopper *A*, passes over a grating *C* to the coal breaker *D*, and mixes with the fine coal passing through *C*, is elevated by *K* to a hopper *M*, falls into a measuring pocket *N* holding one retort charge, drops through the chute *O* into the 20-ft. fire-clay retort. After carbonizing, the stop is removed and the coke runs out, falling into the car below through *U*, and is quenched by the water spray *V*. It is then dumped into an elevator hopper and hoisted to the conveyor and storage bin *S*, from whence it is discharged into cars as desired. The reason why it has not received more attention here is because most new works install water gas apparatus.

The Brouwer conveyor, designed to remove coke after drawing it from the retort by hand, is attracting attention. A flight conveyor passes before the retorts through a trough, as shown in Fig. 2, drawing the red-hot coke along through a current of water going in the other direction, and discharging it into another lateral conveyor in the coke yard. It may be crushed at once, if desired, by switching into the chute shown.

The Consolidated Gas Light Company of New York City has had mechanical coal chargers and coke drawers in successful operation for several years. The coke drawer is shown in Fig. 3. A steam boiler is mounted on a traveling carriage and furnishes steam for propulsion and for operating the three scrapers. Although the workmen would run the machine off the track at first, they soon became reconciled to this labor saver, and would now be just as opposed to going back to the old hand system of charging and drawing. Such mechanical devices as used in Europe do not seem to give the same satisfaction; some operate by hydraulic pressure, rope transmission, compressed air, etc., etc.

Retorts are of fireclay and hold nearly a quarter of a ton of coal, are of ⌓ section, and 2 ins. thick. Improved conveyors, works railways and similar appliances are being now used wherever possible, showing the influence of a few enterprising construction firms. The condenser now mostly used is of the tubular type, resembling an upright tubular boiler, filled with water, the gas passing through the tubes. Washers are vertical vessels filled with a checker-work of square wooden slats crossing each other and constantly covered with water dripping from above. There has been no recent improvement in purifier outside the idea of placing one bed above the other instead of beside it, to save floor space.

Gas holders are now made of steel entirely, on lines similar to those employed in bridge and truss construction. The tank for small holders has been made recently of cement concrete, although steel seems to be more in demand. When the tank is made of brick or concrete, it furnishes a foundation for the guide framing, while a steel tank does not answer that purpose so well, as evidenced by the collapse of the holder in New York just as it was completed. This tank was 178 ft. in diameter and 42 ft. high. Its walls were made of plates varying from 1.5 ins. thick below to $\frac{1}{8}$ in. thick above, and yet

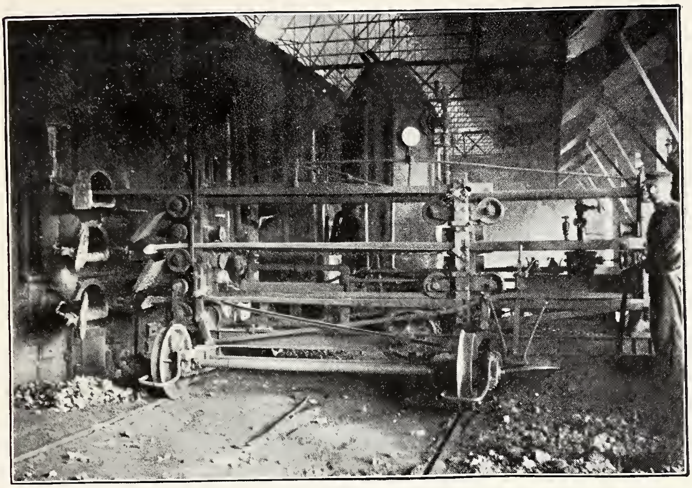

Fig. 3.—Mechanical Drawer for Gas Coke.

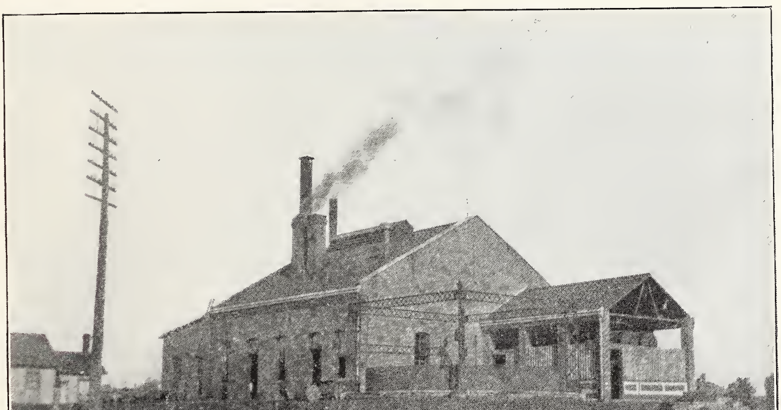

Fig. 4.—Pintsch Gas Plant, Exterior View.

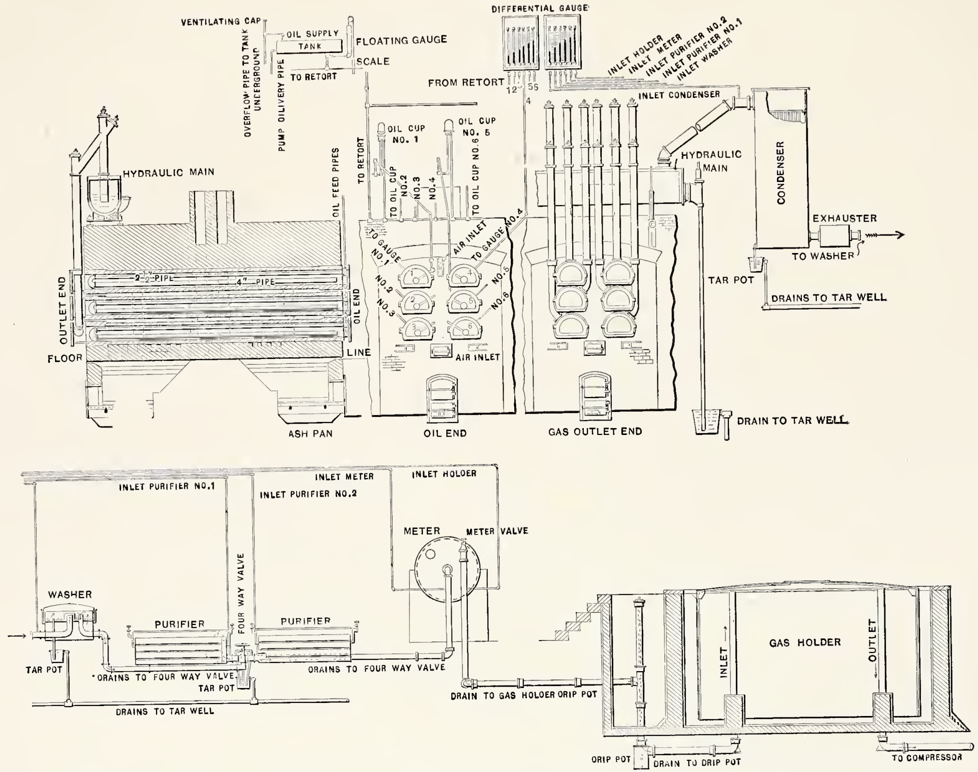

FIG. 5.—ARRANGEMENT OF APPARATUS IN THE PINTSCH GAS PLANT OF THE MANHATTAN ELEVATED RAILROAD.

the entire superstructure rested upon it alone. A lattice coping crowned the edge and under each column was a bracket reaching to within three plates of the bottom. For no reason that was apparent, the entire superstructure toppled over to one side, the side of the tank opened outward and in less than a minute the entire structure was a confusion of twisted shapes and torn and broken plates, for the heavy plates were broken, not torn. The question arises as to whether there is not a limit to increasing size proportionally of standard designs. What may answer for a small holder may need modification for larger sizes. The thick plates were decidedly brittle and were not good material for the purpose. Two facts are forced upon our notice by this fatal disaster; the first is that the sides of tanks of large diameter do not make secure foundations for superstructures, and the second emphasizes the necessity for thorough inspection of all material entering into such work.

Oil Gas.

It has happened in a few cases where oil was cheaper than coal so that vaporized crude petroleum was used for city lighting; but higher prices for oil have sadly discouraged the practice. The Pintsch system of using compressed oil gas for car lighting is, however, of some importance. Cast-iron retorts externally heated were generally used to vaporize oil, but the plant put up at One Hundred and Fifty-ninth Street, New York City, for the Manhattan Elevated Railroad in the summer of 1897 departed from this practice and adopted fire clay retorts. As shown in Fig 4, it is a neat little plant, but the largest of its kind (outside regular gas works) then built, supplying daily 1 100 cars and having a capacity of 150 000 cu. ft. per 24 hours. The oil gas mains are 11 miles in total length, 2 ins. in diameter and carry gas under 14 atmospheres pressure. There are about 40 such plants in the United States. Fig. 5 gives a general idea of the arrangement of apparatus. The oil pipe passes into the retort and returns to near its entrance, by which time the oil is converted into a vapor and passes forward in the highly heated retort. It is thus turned into a fixed gas that condenses very little, and passes out at the outlet end to the hydraulic main (half filled with water) through the condenser, exhauster or gas pump, washer, purifier meter, to the holder where it is stored. Some of the interesting features are the regulation of oil

supply, the close regulation of pressure in the retorts and the compression and storing of gas subsequent to its removal from the holder.

Coke Oven Gas.

Experiments had been in progress several years at Johnstown and Glassport, Pa., for the utilization of gases resulting from the coking of coal before results justified extensive application of the idea. The large plant at Everett near Boston, Mass., which is expected to supply the whole of Boston with gas for light, heat and power is the result of these experiments. It is nearly ready to supply gas, and is probably the most radical step in the gas business that has occurred for some years. As shown in Fig. 6 the works are extensive. Cheap but good coking coal is obtained from the Dominion Coal Company's mines, in Nova Scotia, and brought in vessels to the dock, unloaded into either the 6 000-ton storage bin or on cable cars running over elevated tracks to the 2 000-ton bins over the ovens, or to the yard beyond of 80 000 tons storage capacity. There are eight batteries of fifty retorts each. The retorts are 33 ft. long, 6 ft. high and 18 ins. wide, holding about 6 net tons each in striking contrast to the ordinary gas works retort of 400 to 500 lbs. capacity. As seen in Fig. 7 they are charged by cars running along the top from the two 2 000-ton bins, through *A*, the coal is leveled through a hole *B* in the door *C*. After coking, the doors at both ends are removed, while the pusher, electrically operated as is all other machinery about the ovens, shoves the entire charge from the retort into the quenching car *i* from which it is dumped into the specially constructed railway car.

During the first half of the coking period the gas is rich and is used for lighting, while the last fraction is used for heating the ovens. After passing through the condensers and washers it goes back through the fuel main *H* into the gas flue under the retort. Through a tweer into the air ports *Q* comes the current of hot air from the regenerators *N*, and both pass together through the narrow flues *R'* into the top flue *T'*, thence to the other side of the oven, down similar flues through the other regenerator, through the flue *M* and out of the stack. When the valves are reversed, the current passes the opposite direction. The regenerators save, it is claimed, about 1 300 cu. ft. of gas per ton carbonized. The pusher and loader travel

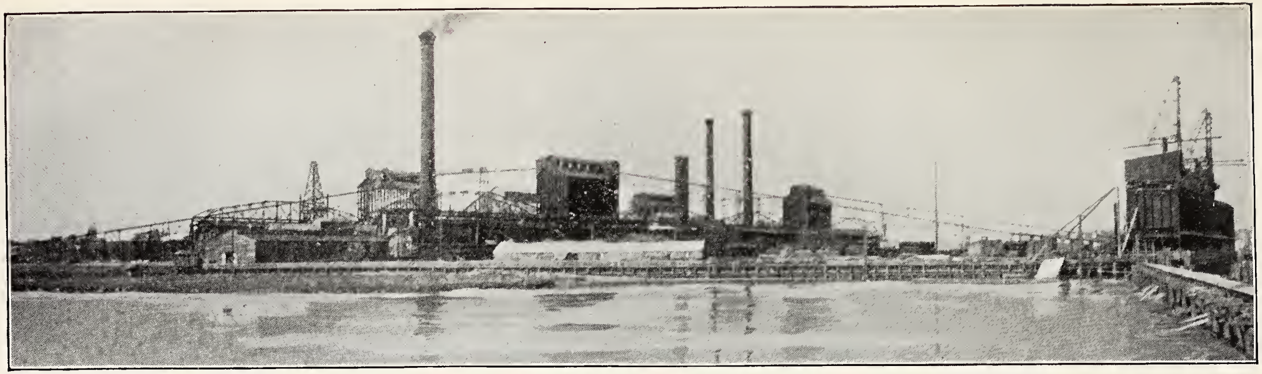

Fig. 6.—General View of the Everett Coke Oven Gas Plant.

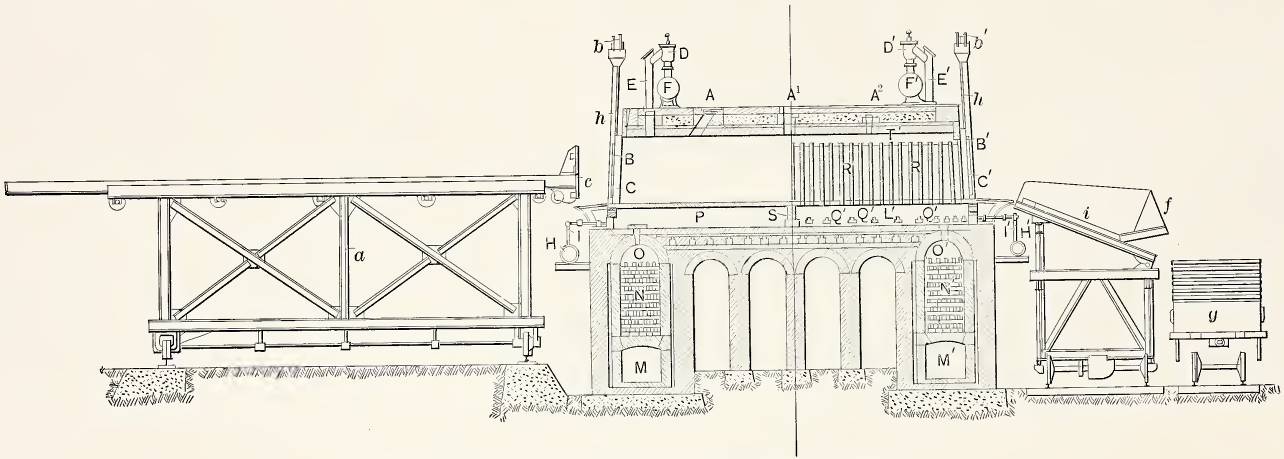

Fig. 7.—Cross-Section of Otto-Hoffman Oven at Everett.

on rails along the side of the batteries. The equalization of pressure in the retort and waste gas flues is done automatically, so that no waste gases at any time can enter the retort.

After leaving the retorts and dry main, in which the tar pots collect some tar, the gas passes through the spray washers, which effectually remove most of the remaining tar; then through tubular condensers, tar scrubbers, exhausters of the Connersville blower type, coolers to remove the temperature due to compression, through the bell washers which remove the ammonia. Here the rich gas goes to the purifying house, and the 5 000 000 cu. ft. holder, thence through the two 42-in. mains of the Massachusetts Pipe Line Company to Boston, while the lean gas is collected in a smaller holder of 50 000 cu. ft. capacity, and goes back to heat the retorts. The lean gas has two sets of washing and condensing apparatus devoted to it, while the city gas has three sets. The by-products of the plant per long ton of coal were found to be by weight:

	Pounds.	Weight, per cent.
Coke	1 593.4	71.13
Tar	75.7	3.38
Ammonia (137% sulphate)	7.6	0.34
Gas, total (10 390 cu. ft. of 0.466 sp. g.)	368.0	16.43
H_2S (0.98 lb. per 1 000 cu. ft.)	10.8	0.48
CS_2 (0.13 lb. per 1 000 cu. ft.)	1.6	0.07
Gas, liquor and loss	182.9	8.17
	2 240	100

About 2 000 tons can be coked in the 400 retorts per day, and one charge requires twenty-four to thirty hours. The coke is expected to replace coal for most purposes, as it can be sold cheaper and is smokeless fuel. The tar is already contracted for by a roofing paper factory. The ammonia has a field among fertilizers, and the surplus gas is also contracted for as soon as it can be supplied.

This coal has a heat value of 1 243.7 B. T. U., and makes half rich and half lean gas.

	Rich Gas.	Lean Gas.
Calorific value, B. T. U. per cubic foot	685.8	566.7
Average candle-power	14.7	9.0
Specific gravity	0.512	0.421

Before being sent to the consumer it will be further enriched to probably 18 C.-P. or more, although recent results led to the belief that no enriching will be necessary. Dr. Schnilwind compares the process with other gas-making processes with regard to the heat utililized of the fuel employed, and finds:

Carburetted water gas	70.0%
Coal gas, good practice	72.9%
Coal gas, poor practice	68.8%
Otto-Hoffman ovens	89.1%

This speaks well for the system of economies practiced in the process. Dr. Carl Schmidt recently took up the discussion of this question in a German gas journal and showed the relative proportion of gases given off during carbonization (Fig. 8).

As the candle-power of hydrogen and marsh gas is nil, and nitrogen and CO_2 are not combustible, the luminosity of the flame depends to some extent upon CO, which is quite constant, but more upon the illuminating hydrocarbons, which quite rapidly decrease, and the candle-power goes with them. That is why a 15 C.-P. gas was obtained during the first half and a 9 C.-P. during the latter half of the coking period. This plant is a novelty, and, as an engineering feat, is carried out on a scale and a degree of confidence in scientific principles that compels admiration. The method, however, is not applicable everywhere, as it is at Boston, and is therefore not apt to be revolutionary.

Water Gas.

The improvements in water gas manufacture have been principally in small but important details of the apparatus. The Lowe apparatus is extensively used, and there is now installed, it is claimed, apparatus of this type having a daily capacity of over 200 000 000 cu. ft. It is made by firms having ample capital and engineering ability. If the price of oil, of which 4.5 to 5 galls. is used for every 1 000 cu. ft. of gas made, increases, some change may result in the relative positions of coal and water gas. The scores of water gas processes exploited ten years ago are things of the past. Occasionally venturesome individuals invade the field with a gas just as good for half the price, but their life is short. The Hall process even now is before us with its

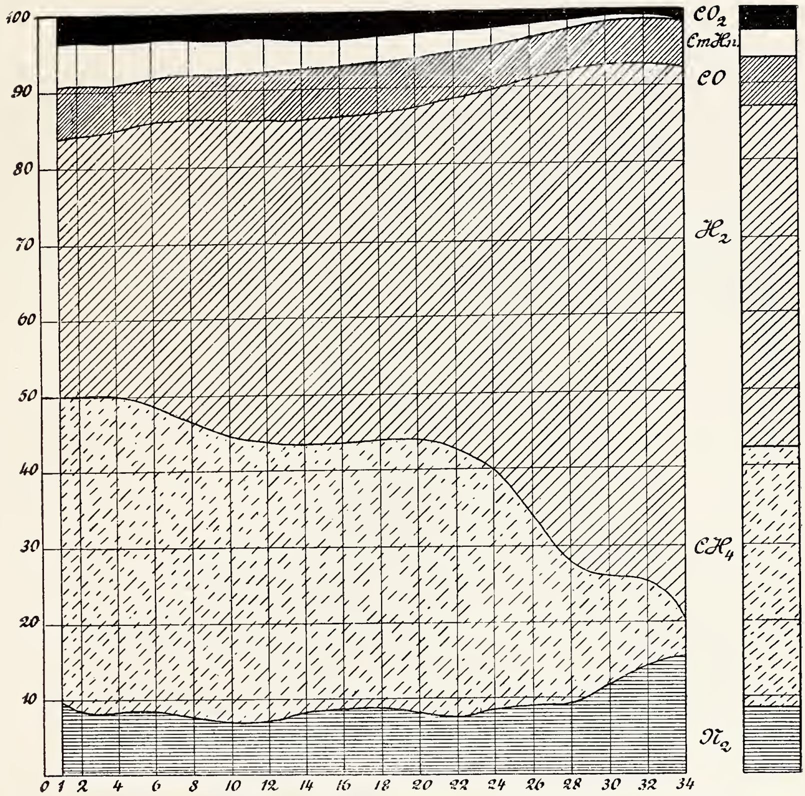

FIG. 8.—DIAGRAM SHOWING YIELD OF GASES DURING COKING IN OTTO-HOFFMAN OVEN.

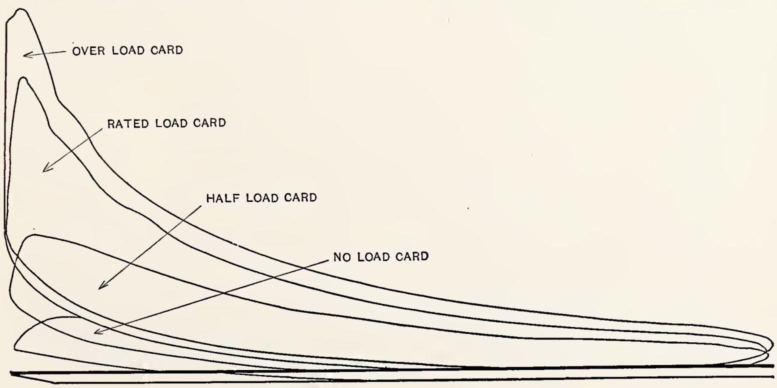

FIG. 11.—INDICATOR CARDS OF WESTINGHOUSE ENGINE.

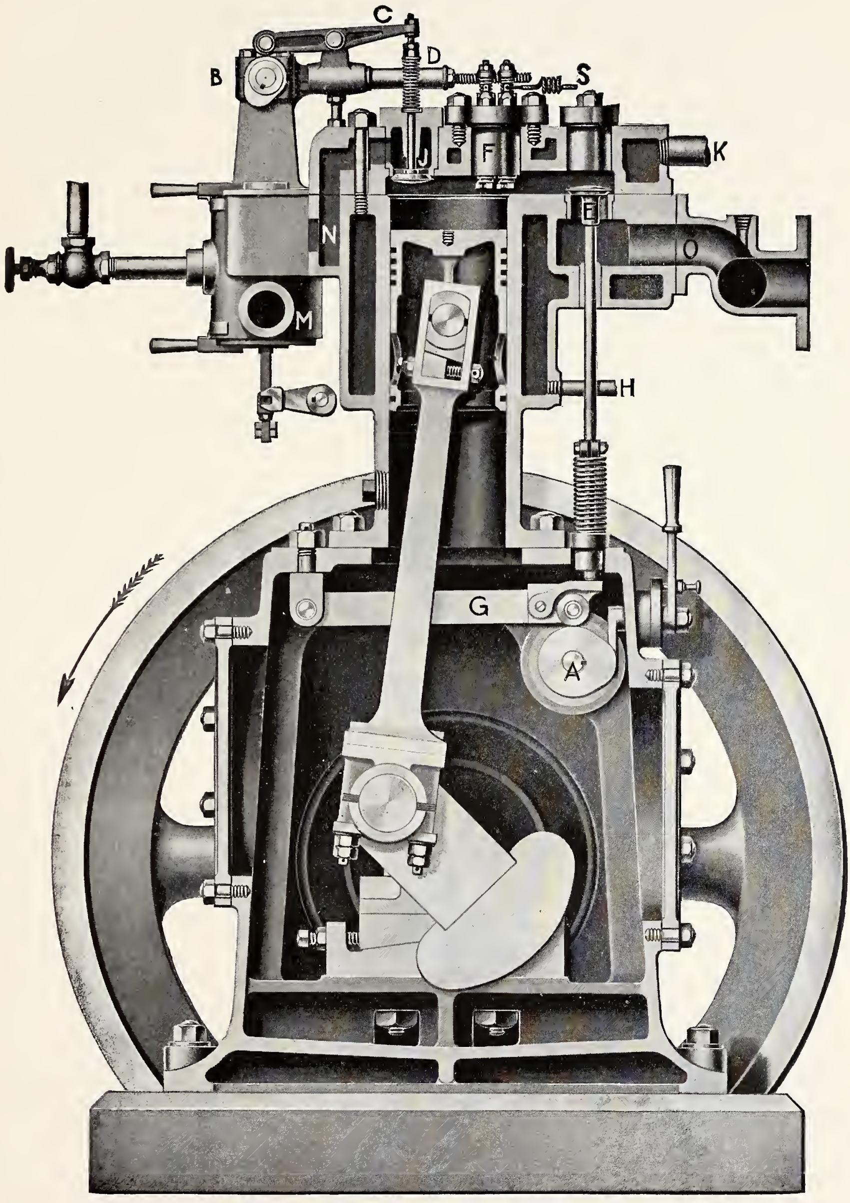

Fig. 9.—Section of Westinghouse Gas Engine.

claim for rendering nitrogen combustible by passing over scraps of brass, zinc and iron and thus "electrolyzing" it, and, strange to say, the promotors manage somehow to secure financial backing. The principal actual progress in this gas has been in the Dellwik process.

The Dellwik Process.

In the ordinary water gas processes while blowing air through the coke or hard coal to bring it to a high enough temperature to decompose steam, the bed of fuel was so thick that the carbon was but partially consumed and CO was formed with the liberation of but 4 327 B. T. U. per pound. If it could have been burned to CO_2 14 500 B. T. U. would have been set free instead, and it would have required the consumption of but one-third the quantity of carbon to attain the same temperature. In the Dellwik process, by reason of a constant and not too deep bed of fuel and a rapid blast of air, there is so much oxygen present in the upper part of the fuel that there is no opportunity for the escape of CO unconsumed, and a maximum heating effect is attained. In the improved Lowe process, the blast gases consist of about equal portions of CO and CO_2 as usually operated. Another advantage claimed by the Dellwik process is that the time of heating up is thus reduced and the time of steaming or gas-making is lengthened; no steam reaches the further surface of the fuel undecomposed, so that the percentage of CO_2 in the gas is kept down. If the steam is forced through too rapidly, it decomposes near its point of exit from the fuel, and the oxygen at once attacks the CO, converting it into CO_2.

There is practically no difference in the composition of this gas and the ordinary water gas before adding enrichers. The principal advantages, then, are the complete combustion of the blast gases and the simplicity of the apparatus. But this simple advantage means much in the economy of operation. An analysis of the blast or heating up gases at Warstein showed the presence of but 1 to 1.8 per cent of CO. This means that 70 000 cu. ft. of Dellwik water gas is produced from a long ton of coke as against 34 400, the average of old processes, or, that Dellwik gas contains 82% of the heat units in the coke as against the ordinary European water gas plants giving but 40% (although our water gas has a somewhat higher yield). And this is done by substituting a blasting period of two minutes, and a run of seven to ten

minutes, the old method requiring blasting ten minutes and making gas four to five minutes.

The results are so much better than are gotten elsewhere and the reports of every one of the many scientific men of prominence who have examined the process agree so well and are so favorable that it must be acknowledged that Germany has given us a decided improvement in the manufacture of water gas for fuel purposes.

Gas Engines.

Gas for power is a convenience, and where gas can be had for less than 50 cents per 1 000 ft, it is an economy. No expensive boiler plant nor labor is necessary. One good mechanic can attend to an ordinary plant, and the best engines require very little attention outside the igniters. Small gas engines formerly limited the field of these motors and the poor regulation when operated upon the hit and miss principle excluded them from many applications. In the natural gas district this gas can be obtained at from 10 to 25 cents per 1 000 cu. ft. and as it has a high calorific value, it was there that gas engines received their first serious introduction. It soon became necessary to have better regulation and the Westinghouse Company began experiments upon regulating the supply of gas at each charge in proportion to the load and used the ordinary centrifugal throttling ball governor with such good effect that they disregarded the hit-and-miss principle altogether, along with the single cylinder.

As these gas engines regulate within 2%, they are well adapted for driving electric light plants, and are used, among others, by the gas companies at Long Branch, N. J., and Columbus, O., for that purpose in 280 H-P. three-cylinder, direct connection sizes.

The section, Fig. 9, gives an idea of the construction of these engines. They are started by compressed air which is stored up while the engine is running or supplied to the tank by hand. Where gas is not available, gasoline is used to carburet air, making a gasoline gas which gives good results. Perhaps the largest gas engine running today is a Westinghouse 650 H.-P, direct connected. It has been in operation several years and demonstrated the fact that the efficiency increases with the size. It is shown in Fig. 10. In consequence there is one now under construction in their shops which will have a brake horse-power of 1 500. Indicated horse-power is unreliable with all

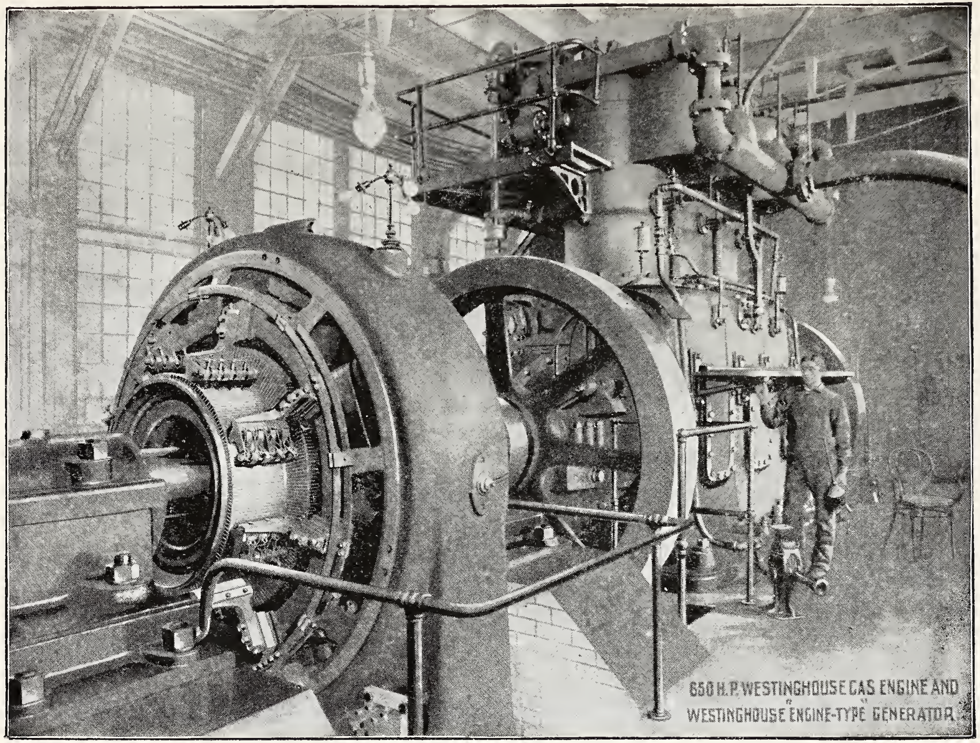

Fig. 10.—A 650-Brake-Horse-Power Gas Engine.

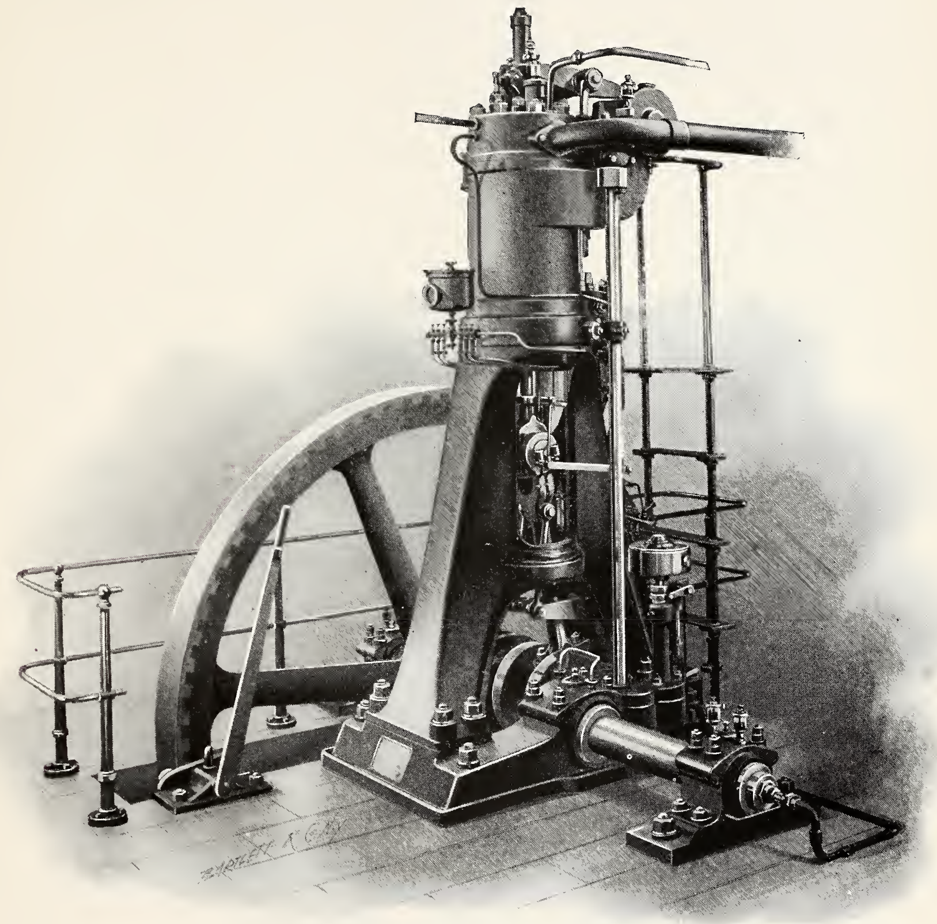

Fig. 12.—A 20-Horse-Power Diesel Motor.

forms of explosion motors for obvious reasons, and brake horse-power should be required in all specifications. Cards from one of these engines are shown in Fig. 11, which shows plainly the effect of throttling the gas admission and prolonged explosion.

The Diesel Motor.

Trouble with igniters has always been a drawback to the satisfactory operation of gas engines and that is one of the reasons why the announcement by Rudolf Diesel in 1893 that ignition could be effected by compressing the charge to the temperature of ignition of the fuel attracted so much attention. His original ideas were not strictly carried out, but this principle of high compression was, and an engine was built which gave very encouraging results. A number of these engines are in use in Germany and a company has been organized in this country for their manufacture, although they are not yet on the market.

The single cylinder type is 20 H.-P., and the one shown in Fig. 12 was exhibited at the Electrical Exposition in 1898. A three-cylinder motor is running at Augsburg, Germany, of 150 H.-P. At the present time they use oil, but experiments with gas have given very good results. Fig. 13 is a cross-section. It operates something like this: On the down-stroke the cylinder is filled with air, the up-stroke compresses it to about 35 atmospheres and a temperature high enough to ignite the fuel, which, in this case, is petroleum injected under pressure and atomized through gauge by compressed air during any part of the stroke as desired and thus producing combustion in place of explosion. The compressed air, which comes from an attached air pump, is stored in a tank and passes through an oil injector valve operated by a lever and cam. The piston then returns, expels the gases of combustion and takes in a fresh charge of air upon the down-stroke. The compressed air cylinder furnishes power to start the motor. Notwithstanding the high compression the engine runs very smoothly and with good regulation. Great economies are claimed for it and a heat utilization efficiency ranging from 23% at half load to 29% at full load.

A 100 H.-P. Diesel motor consuming 240 grams of oil per B. H.-P. hour at prices varying from 1 to 3 cents per gall. will cost about 15 cents per hour. A good steam engine of the same size with coal at $2.80 per ton will cost about 54 cents for a slide valve, 43 for a Cor-

liss, and 22.4 for a triple expansion engine. To this should be added, of course, the expenses of larger plant than is required by the oil engine. Colonel Meier, the engineer for the company, is responsible for the following interesting calculations, giving the comparative heat efficiency of the motor:

	Heat utilization.
Small auxiliary steam engines, pumps, etc. .	0.6 to 1 per cent.
Plain slide valve engines, good condition . . .	3 " 5 "
Single cylinder Corliss engines	6 "
Compound condensing engines	8 "
Reheating compound or triple expansion steam engines	12 "
Best oil engines (explosion type)	16 "
" gas " " " hit and miss.)	19 "
Diesel combustion motor	28 " 30 "

The Westinghouse engine might come in here with its efficiency of 20 to 25 per cent. There are some Diesel motors in daily operation in this country one 60 B. H.-P. in St. Louis, costing $\frac{1}{5}$ cent per horse-power hour. They will also be made to use gas. The question of competition at once suggests itself, but we may safely dismiss it with the remark that there is room for everything of excellence, and that its niche cannot be so well filled by anything else as itself. Steam power need have no immediate fears due to the development of gas power. Fig. 14 is the American version or design of the Diesel motor, and is interesting in connection with Fig. 12, as comparing American and German designs of the same apparatus. Fig. 15 shows cards made while using coal gas.

Acetylene Lighting.

As is probably well known, acetylene is a concentrated hydro-carbon gas consisting of equal parts by volume of carbon and hydrogen with a small percentage of impurities such as phosphuretted and sulphuretted hydrogen, and possibly a little marsh gas. It is generated by the very simple action of bringing calcium carbide into contact with water when the gas is at once violently evolved, leaving slaked lime as a residue. The very simplicity of the operation has led men of inventive propensities, from professors to tinsmiths, to devise and patent generators for the work, so that generator patents are issued at

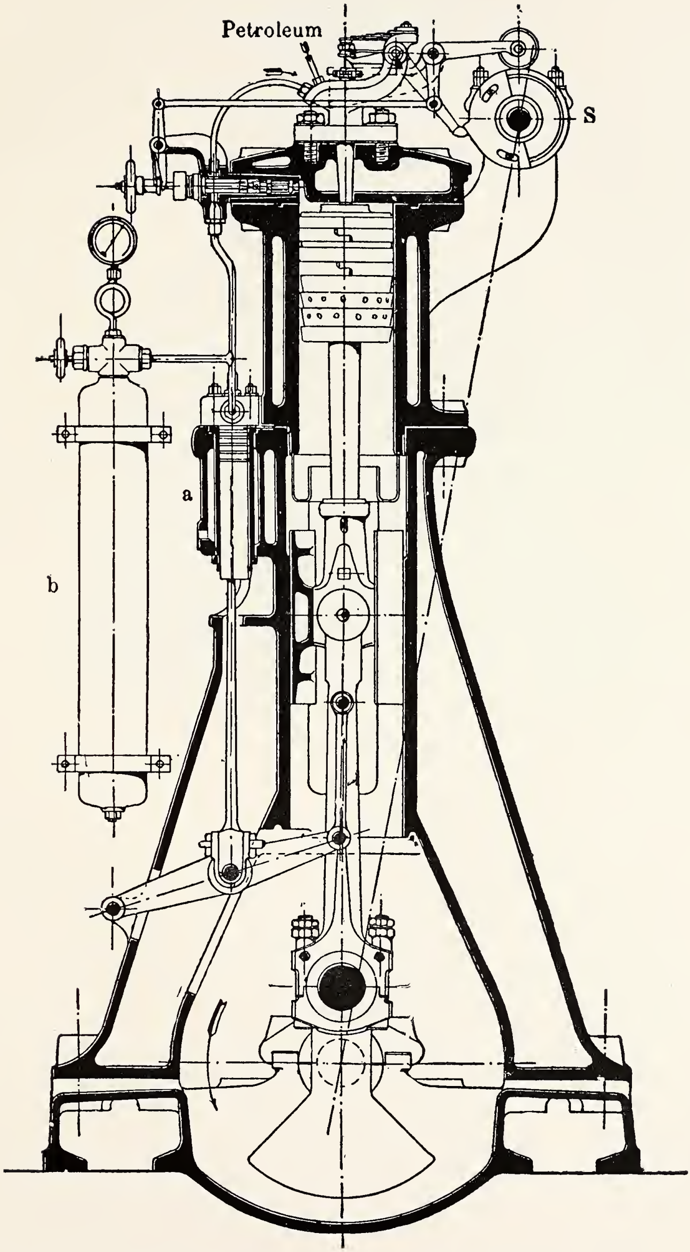

FIG. 13.—SECTION OF DIESEL COMBUSTION MOTOR.

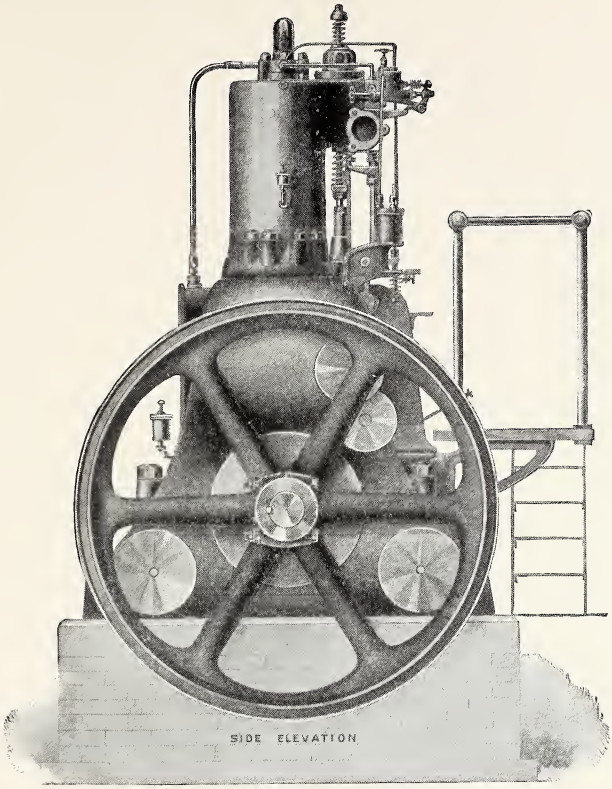

Fig. 14.—Diesel Motor. Designed in America.

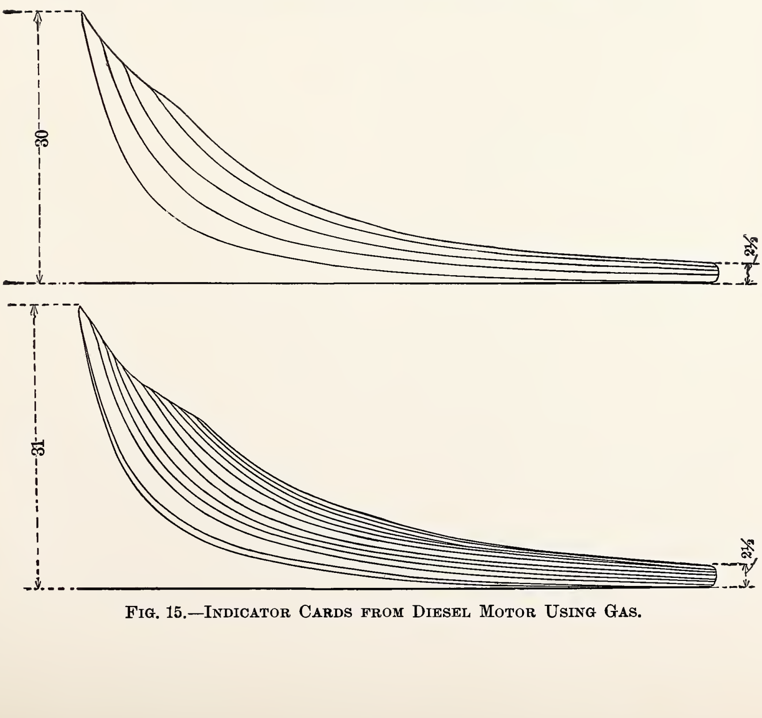

Fig. 15.—Indicator Cards from Diesel Motor Using Gas.

the rate of about half a dozen per week. The gas has an intensely luminous flame, a 25 C.-P. light requiring the consumption of but ½ cu. ft., while 5 cu. ft. of our city gas are necessary for the same luminous effect. A peculiar burner is necessary for the best results however, for the gas is so rich in carbon that it is liable to smoke. The burner, therefore, is built upon the air-injector principle, the gas orifice being flanked by air openings, so that it passes into the flame through the principal burner orifice having an envelope of air between itself and the steatite tip. If the heated gas comes in contact with the steatite itself, the latter is liable to absorb tar from the gas, and upon this as a basis very curious fins of graphite an inch or two in length are often formed, which clog up the burner finally, and in any event cause it to smoke. The present types of burners on the market answer the purpose well; and the method, as a method of lighting, is quite satisfactory for isolated localities where city gas is not to be obtained, or where electricity is charged for at exorbitant prices. For city lighting the question is, however, still an open one. Several small villages have adopted acetylene lighting with more or less satisfaction, for, as in generator construction, the simplicity of the process leads every amateur to imagine he can master the situation. There is, therefore, considerable trouble from lime deposits in the mains and service pipes, and tar stoppages at the burners, to say nothing of leaks and occasional explosions to vary the monotony.

At New Milford, Conn., in May, 1898, an acetylene plant was installed to compete with electricity. The town has a population of 2 500, and over half were said to have used this gas a year ago. Four generators were coupled and connected to a gas holder having a capacity of 300 cu. ft., and supplied consumers through a 3-in. main put in shallow trenches. About 180 lbs. of carbide were charged per day. Ordinary gas meters were installed, and the price of gas was $20 per 1 000 cu. ft. Milford, Pa., a Pike County village near Port Jervis, about the same time had a similar plant of about the same capacity. A gas pressure of 2¾ ins., hydrostatic, was used. Probably the most interesting plant, however, was installed at Wabash, Ind., a city of 12 500 inhabitants of an enterprising character, for it is claimed that it was the first city to be lighted by electricity. It was formerly lighted by natural gas used in Welsbach burners, and oil gas varying in price from $2.50 to $3.70 per 1 000 cu. ft. The latter plant was

given up, and the 200 cu. ft. capacity relief holder, and the 6 000 cu. ft. storage holder are now used to store acetylene.

Fig. 16 is an exterior view of this plant, and Fig. 17 a section of the acetylene generator employed. The ordinary city gas meters are used, and the gas is sold on a basis of 16 C.-P. hour units at ½ cent per unit, with discounts not stated. As a 25 C.-P. hour requires ½ cu. ft. of acetylene gas, this unit would equal about one-third of a cubic foot, and is equivalent to a price of $15 per thousand. The burners consume 0.5, 0.75 and 1 cu. ft. per hour, and, owing to the principle of wet generation, little trouble is experienced with stoppages. A very interesting thing occurred on August 7th, however. When the attendant returned to the plant he found that the building had disappeared, and that the generator was gazing at him like a Phœnix rising from the ruins. A leak had evidently occurred about the apparatus somewhere, and gas gradually accumulated until in explosive proportion, was ignited by a gas flame left burning in the room—another amateur trick—and an explosion occurred which very effectively cleared the way for a new structure. This lesson has long ago been learned in the gas business. No open flames should be permitted in rooms where gas is liable to collect. The gas holder was not injured, and the plant never ceased for an hour to continue supplying gas to consumers.

Miscellaneous.

Among other new developments which are demanding the attention of gas engineers are such subjects as distributing gas under pressure. As the demands of a district increase, more gas must be conducted to it than the main will carry, and the expense and inconvenience of putting in a new pipe is sufficient to make the manager do some hard thinking. This increased demand is to-day staring many managers in the face, for gas consumption has more than doubled in this country within the past decade, so that the supplying of outlying distributing holders or adjacent towns with gas by forcing it through the pipes under a pressure of several pounds per square inch is being thought of seriously. Experiments have shown that it can be done without reducing candle-power, and without abnormal leakage or expense for pumps and power, so that we may soon expect to see it applied.

Electrolysis is also demanding a solution. Whether the more extended use of cement joints, which are excellent as far as tightness is

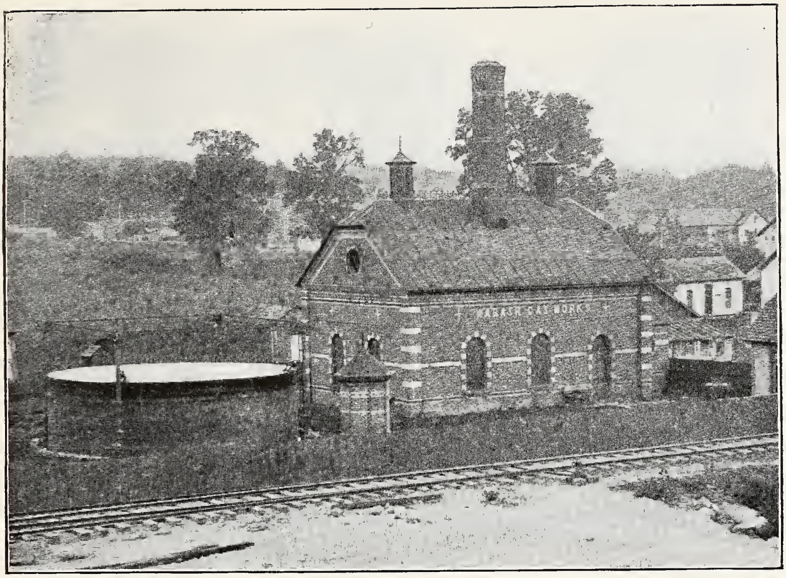

Fig. 16.—Wabash Acetylene Gas Plant.

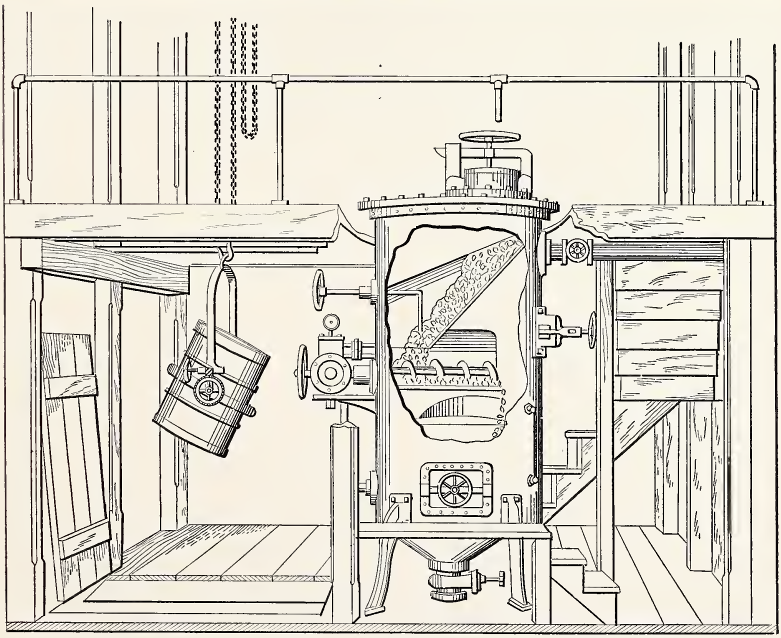

Fig. 17.—Section of Acetylene Generator Used at Wabash.

concerned, or the use of vitrified clay pipe instead of cast iron, will be extensively experimented with remains to be seen, as the subject is still under discussion. The use of gas for fuel purposes is growing, and the discussion has originated in Germany as to whether we had not better give up the manufacture of a luminous gas altogether, and make a cheaper gas of high calorific power, using it in Welsbach mantles for lighting, and thus save the expense for oil used to increase candle-power. Oil has become quite expensive the past two years, having about doubled in price, and there may be localities where this policy would be of advantage. Certainly the use of gas for heating purposes is increasing remarkably. Uncarburetted water gas and simple coal gas are considerably cheaper and answer equally well for all purposes, except open flames, so that as the number of the latter decrease it becomes a question as to whether the tail shall wag the dog. In the matter of efficient apparatus for heating and lighting there is no doubt but that America is ahead. Our gas stoves are beautiful in design, and are certainly, very efficient, and the variety offered in the way of domestic heating, cooking, and laundry purposes, is sufficient for all requirements. The growth in the demand for the Welsbach light must not be overlooked. Where care is taken with mantles it is by far the most efficient method of general lighting employed to-day. Contrary to expectations electricity had a rather stimulating effect upon the gas business, and its growth has been correspondingly rapid. There are uses for which gas is pre-eminently fitted, and their development promises much for both the gas engineer and the gas consumer.

DISCUSSION.

The President. The PRESIDENT.—Mr. Landis has given us a very good idea of what is going on in gas manufacturing, and I think it is a subject of very great importance. I know that some years ago, when the lighting of the city by electric light was in progress, a good many folks said that gas was going to be a pretty poor thing. But I was informed by the chemist of one of the large gas companies of New York that during the period from 1880 to 1890 and perhaps a few years later than that time, when electric light plants were coming into use, there was no time when New York City had enough gas plants to perform the full duties that were required of them with any reserve for safety. There were times when, at the end of the week their gasometers were empty, and it was only by the smaller consumption of Sundays that they were able to keep up with the demand and get a little surplus to go into the next week, and a serious break-down at any of the works would have occasioned the shutting off of gas from a good section of the city. That was the condition when they were building up works that nobody on the outside understood, and, apparently, the importance of the gas business is still recognized by New Yorkers, besides the building of new plants. For instance, we know what happened at Albany last year on the proposition to build enormous works at Astoria and to fight for gas.

The projection of the Ravenswood Works that has been shown to you this evening shows what New York demands in the way of gas. After all the talk there has been of building tunnels under the East River for the purposes of communications it rested with a gas company to actually build the tunnel and show what was possible in the way of tunneling under the rock of Blackwell's Island.

Mr. Ford. Mr. W. G. FORD.—I would like to ask what proportion of American cannel coal is used in the production of gas?

Mr. Landis. Mr. LANDIS.—As far as I am informed, there is very little used for this purpose in the United States. The American cannel coal is used principally in open fire-places. Very little of it is used in the manufacture of gas as we have gotten into the habit of carburetting with oil instead of cannel coal. We are not satisfied with the low candle-power gas sold in England where the cannel coals are used for enriching, but use oil in order to bring it up to 20 or 22 C.-P.

Mr. Meem. Mr. J. C. MEEM.—I would like to ask a commercial question. Suppose a town of, say 5,000 people, to have a gas plant, would it pay them to put in a by-product apparatus with such a small plant as that?

Mr. Landis. Mr. LANDIS.—It would to a limited extent. It would pay to take out the tar compounds, because it has to be done in order to light effectively, and while you are taking out the tar you might as well take it out in such a form that it can be disposed of commercially.

Mr. J. C. MEEM.—That apparatus, I presume, is not very extensive. Mr. Meem.

Mr. LANDIS.—No; it consists of a condenser, scrubber and purifier. Mr. Landis. The tar has to be taken out anyway, and likewise all the ammonia and sulphur compounds have to be removed. The tar would deposit in the pipes and burners and clog them; the ammonia, if burned in the atmosphere of living rooms, would generate poisonous cyanides, while sulphur compounds would form sulphurous gases injurious to health. While you are removing these impurities you might, therefore, as well remove them in such a form that you can employ them for some commercial purpose. There is a market for tar and ammonia compounds, but none for the recovered sulphur.

THE ANNUAL DINNER.

The Fourth Annual Dinner of the Club was held at "The Argyle," 153 Pierrepont Street, on Thursday evening, December 14th, 1899, at 7 o'clock.

Walter M. Meserole, President, acted as toastmaster.

Joseph W. Roe spoke on the "Chase of the Automobile"; Frederick S. Woodward on "Girdling the World in Twenty Minutes"; Henry B. Seaman on "Corporations *vs.* the Cold World," and Willard S. Tuttle on "Why the Castings Come Out Wrong."

The Club quartette, F. W. Perry, first tenor; F. J. Conlon, second tenor; F. L. Bartlett, first bass, and J. Calvin Locke, second bass, gave a number of selections, one of which "Fairy Tales," being a roast on many of the members, was, perhaps, the hit of the evening.

THE JUNE DINNER.

The Second Annual Dinner to the Ladies was held at the Clarendon Inn, on the Ocean Cycle Path, on June 8th. Many of the members and their guests came in parties awheel. Individual tables tastily decorated with seasonable flowers, seating from four to eight, were arranged under the direction of the Entertainment Committee upon the north piazza of the Inn. Music was furnished by an excellent Hungarian orchestra.

Geo. W. Tillson, Chairman of the Entertainment Committee, acted as toastmaster.

Ex-President Nelson P. Lewis responded to the toast "The Club's Future." James Cowan Meem defended "Our Benedicts." George F. Rowell discussed "The Engineering Press." "The Suburbanite" was cleverly handled by Joseph Strachan, and President Walter M. Meserole responded to the toast to "The Ladies." The speeches were interspersed with vocal selections by Members Frank J. Conlon and Fred. L. Bartlett. Through the kindness of a talented member printed copies of a song written for the occasion were available, and a most enjoyable evening was brought to a close in a happy manner by one and all singing the song to a familiar air, led by the orchestra.

Gracie Sayre Roberts.
Memoir of Mr. Roberts was printed in the *Proceedings* for 1898.

George W. Wundram.

MEMOIR OF GEORGE W. WUNDRAM.*

DIED NOVEMBER 9TH, 1899.

George W. Wundram was born at Kirchweihe, near Bremen, in the Kingdom of Hanover, January 1st, 1838. He received his education at local schools and served an apprenticeship as a machinist. He then entered the Hanover Polytechnic and, upon graduation, was employed as engineer by the Hamburg American P. A. Co.

He came to the United States in 1863 and engaged in the manufacture of steam boilers under the firm name of Wundram, Griffith & Co., New York. He was Superintendent of the Staten Island Railroad Company during 1877 and 1878.

He was connected with the Brooklyn Water Department as Architect and Civil Engineer for seventeen years, which position he held at the time of his death. The design and construction of many of the pumping stations and buildings on the line of the Water Supply between Brooklyn and Massapequa were executed under his supervision. He was elected Corporate Member of the Brooklyn Engineers' Club on January 7th, 1897, very soon after its organization, and retained an active interest in its work until his death. He was also prominently connected with a number of German Technical Societies, being one of the organizers of the first of these societies which was founded in New York City in 1864. He held for many years important positions in these societies.

He was also a very active member of the Photographic Section of the Brooklyn Institute of Arts and Sciences.

* Abstract from *Mitteilungen des Deutsch-Americanischen Techniker-Verbandes*, December, 1899, translated by F. O. Nowaczek, Member of the Brooklyn Engineers' Club.

MEMOIR OF JOHN H. VAN DER VEER.*

DIED DECEMBER 2D, 1899.

John H. Van der Veer was born on March 28th, 1864, at Somerville, N. J. His ancestors were among the early Dutch colonists.

While a grammar school pupil he passed the entrance examinations for the United States Naval Academy at Annapolis, but was not admitted on account of his youth.

He prepared to enter Stevens Institute, but in 1881 was obliged to forego his plans and entered the employ of the Central Railroad of New Jersey.

He began as office boy, but displayed such ability that in the short space of three years he was made chief clerk of the freight department and was also given charge of the harbor transfer work.

On December 24, 1888, he resigned this position to become superintendent of the People's Street Railway of Scranton, Pa., one of the first street railways operated by electricity. The following year he became manager of the company and continued in this position until the spring of 1892.

On September 1, 1892, he became connected with the freight department of the Erie Railroad, but in 1893 he resigned from this company to assume the duties of assistant superintendent of motor equipment and maintenance of the Brooklyn Heights Railroad Company.

The successive consolidations entered into by this system increased Mr. Van der Veer's duties, but that his ability was superior to the increasing responsibilities is evinced by the fact that at the time of his death he was superintendent of shops, having under his charge the entire rolling stock of the Brooklyn Rapid Transit Company, both surface and elevated.

Mr. Van der Veer was a charter member of our Club and was actively interested in it. He was also a member of the Railroad Club of New York City. He was a delegate to the National Street Railway Convention held last October in Chicago and read a very able paper on "The Care of Car Equipment."

Mr. Van der Veer possessed the sturdy virtues of his Dutch ancestry. Always too busy to enter much into social life and devoted to his wife and son, the fine quality of his character impressed those fortunate enough to know him well.

"He had kept the whiteness of his soul
And thus men o'er him wept."

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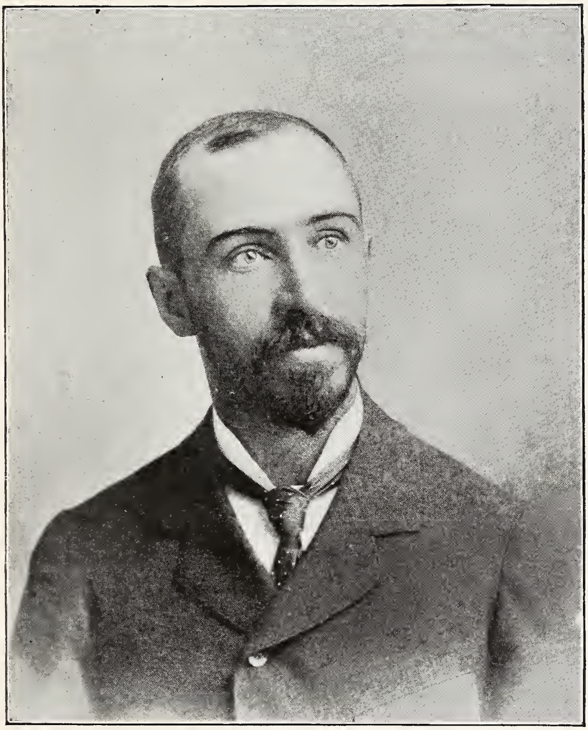
*Memoir prepared from records of the Club and by J. S. Langthorn, Member of the Brooklyn Engineers' Club.



John H. Van der Veer.

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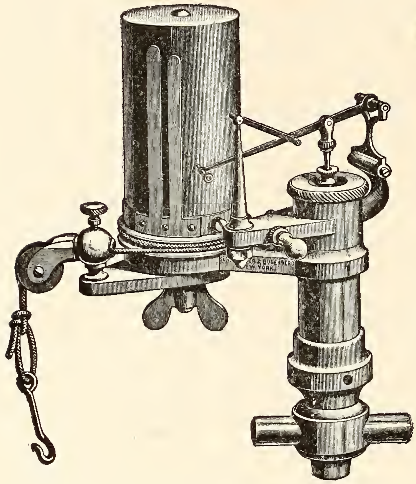

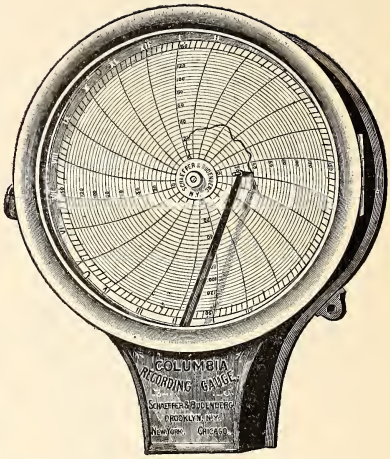

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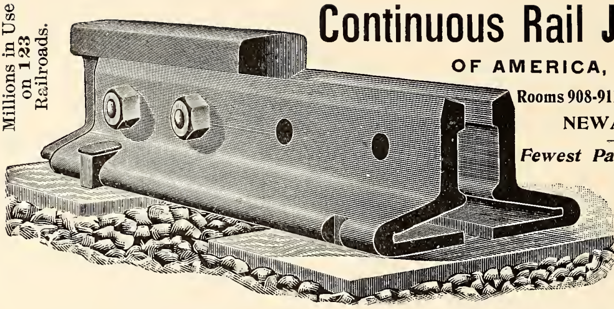

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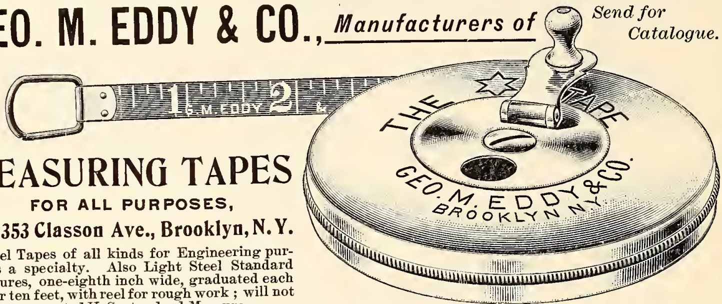

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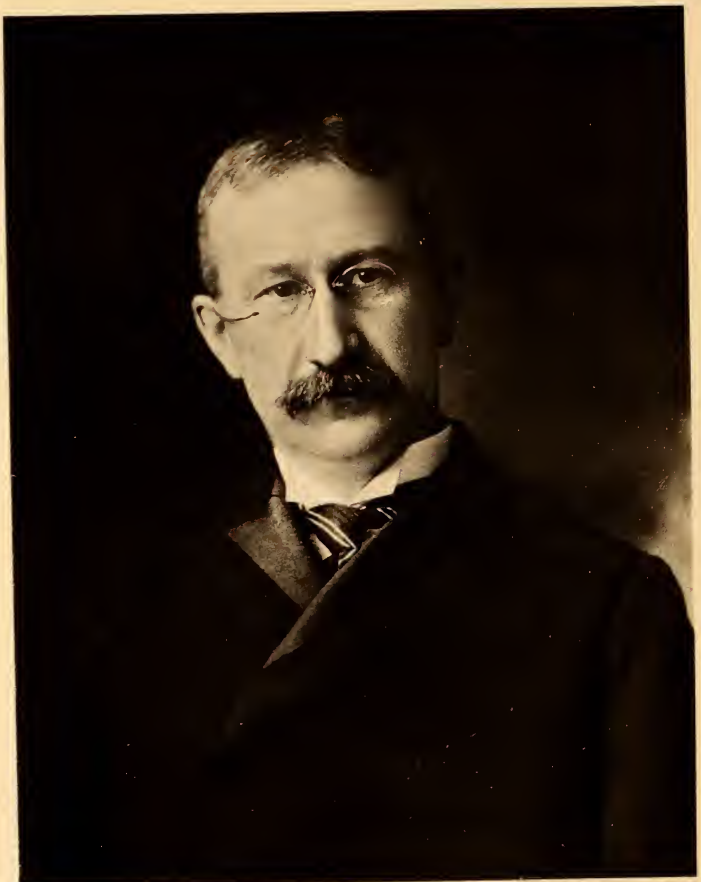

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